# Karlsruhe Chart of the Nuclides
# Nuclear Data in Nucleonica

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**Joint Research Centre**

# Overview

Nuclide Charts

Karlsruhe Chart of Nuclides

Electronic Nuclide Charts in Nucleonica

Nuclear Data Search in Nucleonica

# Nuclide Charts

Nuclide:
A type of atom specified by its atomic number Z, mass number A and energy state.

A nuclide can be specified by the notation:

$${}^{A}_{Z}X_{N} \qquad {}^{60}_{27}Co_{33}$$

where Z is the atomic (proton) number, A is the mass number, N is the neutron number (N=A-Z), and X is the chemical element symbol.

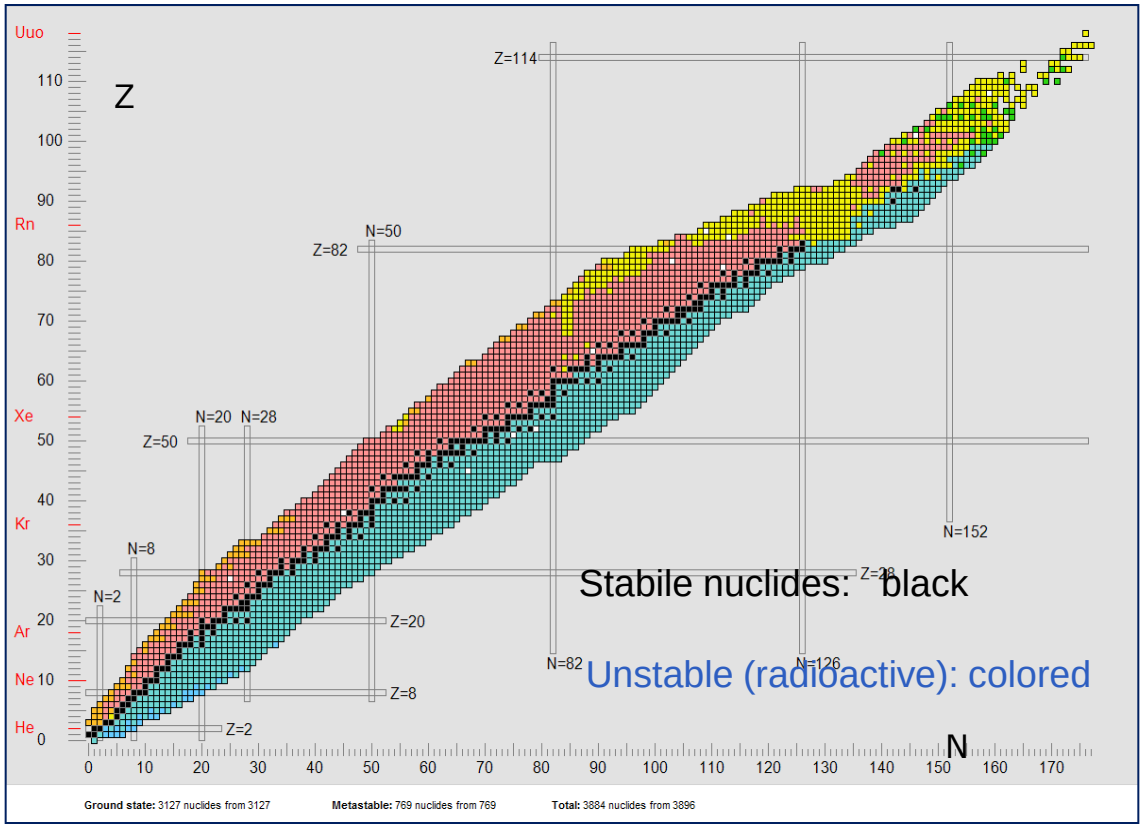
More than 3800 nuclides are known, but only about 10% of these are stable.

# What is a Nuclide Chart?

Nuclide charts are essentially a plot of the number of protons versus the number of neutrons in atomic nucleus.

Stable nuclides fall in a narrow range of neutron to proton ratio.

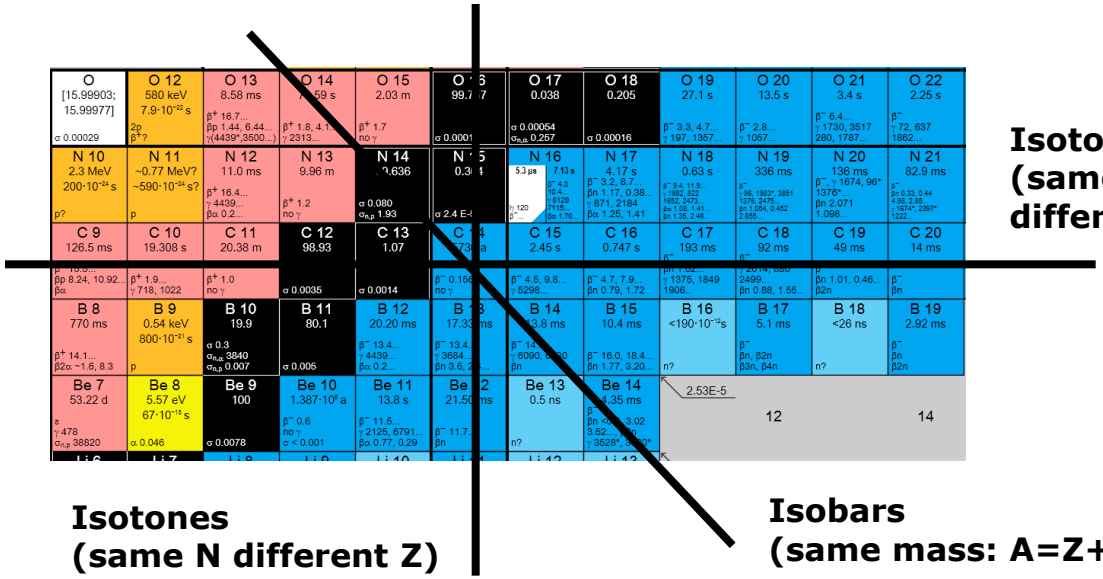
The stability of nuclei is extremely significant for special (magic) number of protons and neutrons.



# Nuclide boxes

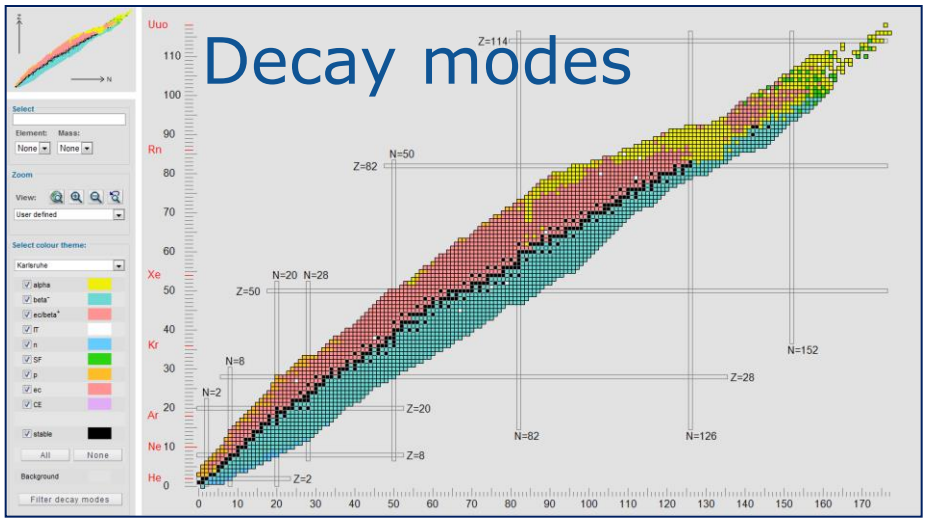
The charts contain information on the basic properties of known nuclides.

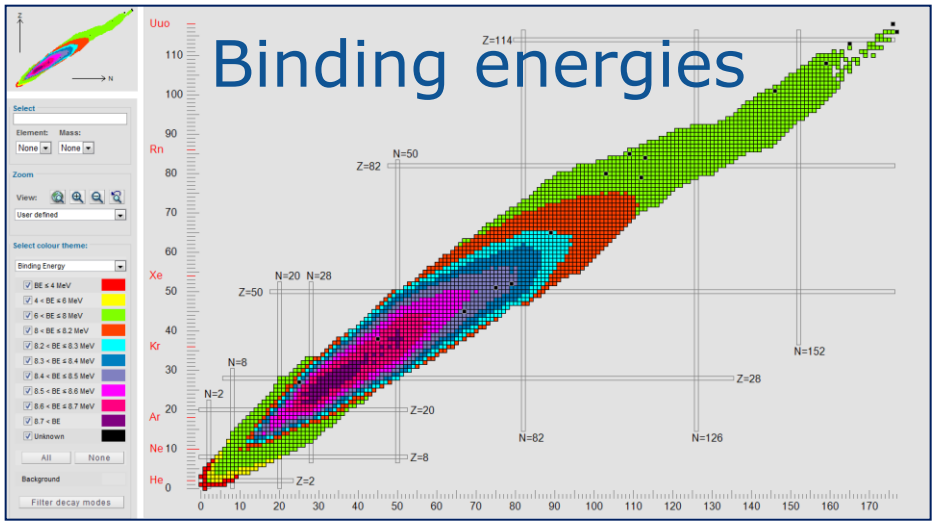
Each nuclide is represented by a box containing basic nuclear data

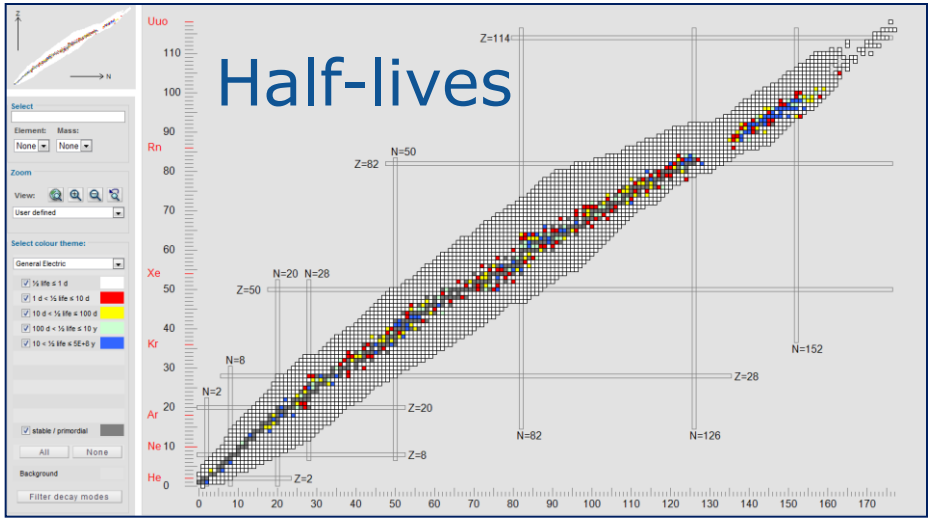


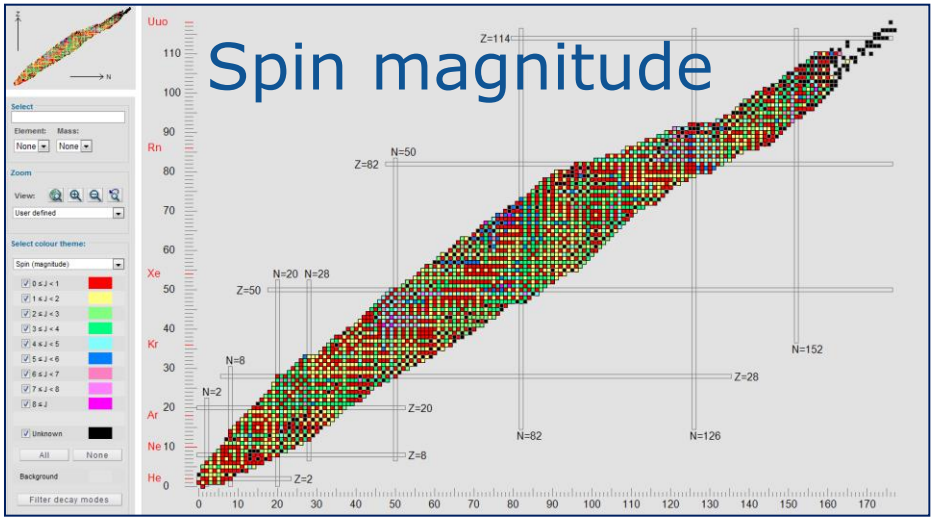

This data consists of the half-life, neutron cross sections, main gamma lines, etc… An important characteristic of the chart is the use of colours to denote the mode of decay, half-life, or cross-sections. If the nuclide has one or more meatstable states, the box is subdivided into smaller boxes for each state.

# Different colour schemes



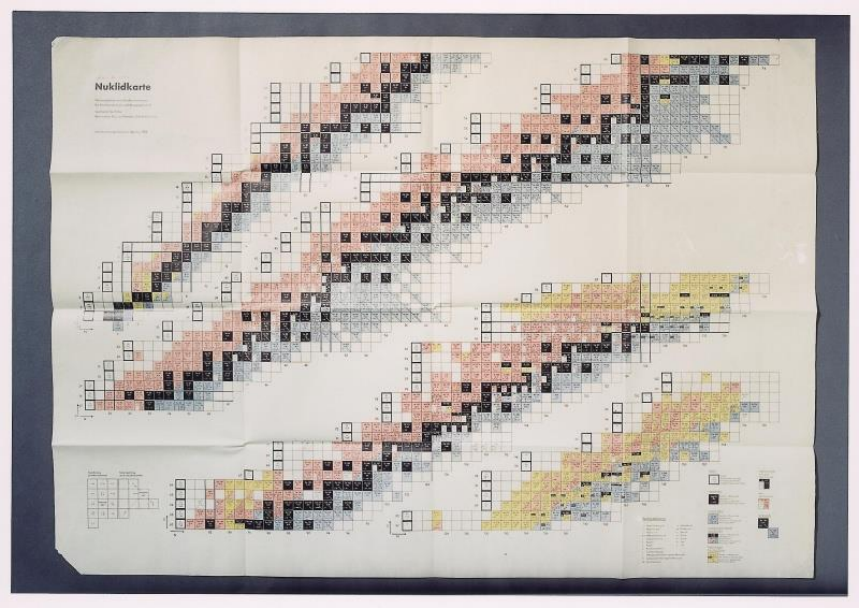



# Nuclide Charts world-wide

| Name | | Colour scheme |
|---|---|---|
| Karlsruhe (Germany) | - | decay modes |
| Strasbourg (France) | - | decay modes |
| General Electric (US) | - | half-lives |
| JAERI (Japan) | - | half-lives |

# Karlsruhe Chart of the Nuclides - KNC




1st Edition in 1958

1517 ground states and isomers

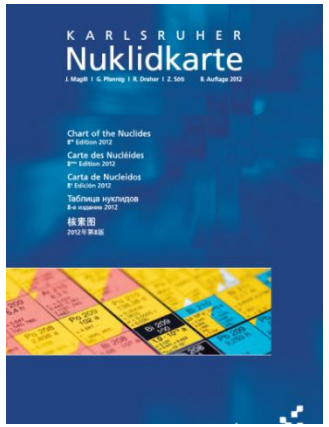
7th Edition in 2006

3654 ground states and isomers, ITU (EC): J. Magill

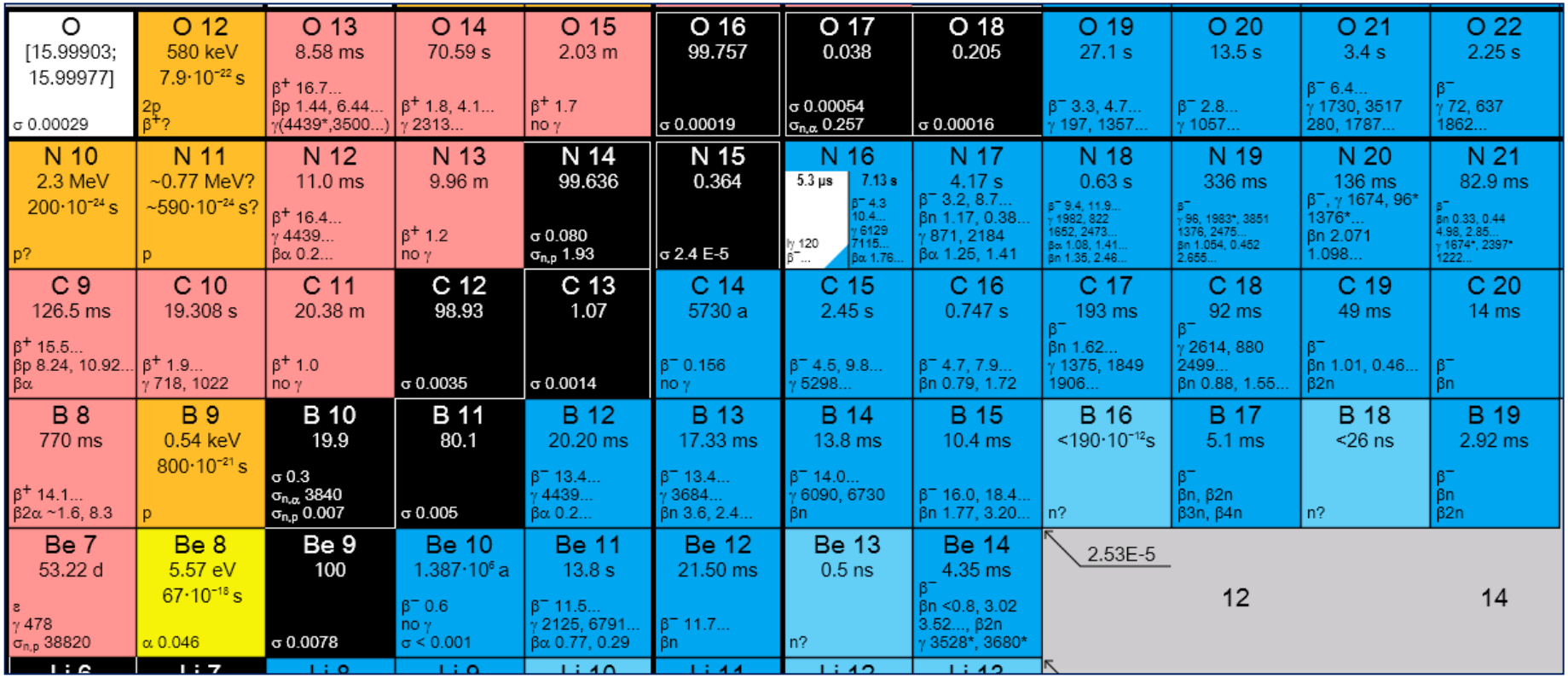
8th Edition in 2012; 3847 ground states and isomers; ITU and Nucleonica spin-off

http://www.karlsruhenuclidechart.net

http://www.nucleonica.com



# KNC – Colours of decay modes



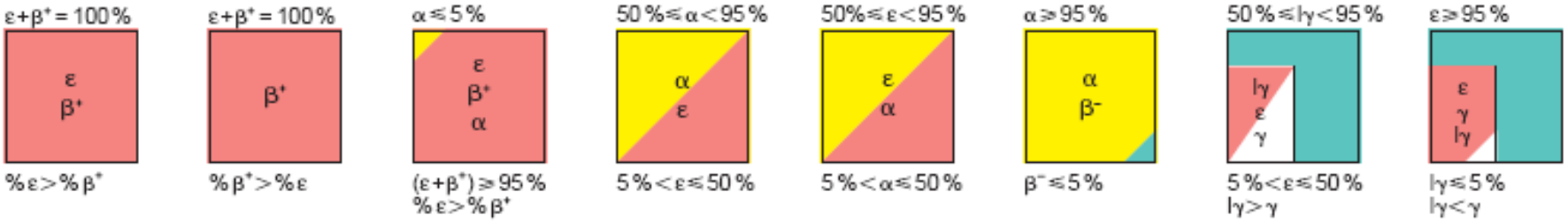

Chemical elements - white

# Multiple decay modes
# Large and small triangles

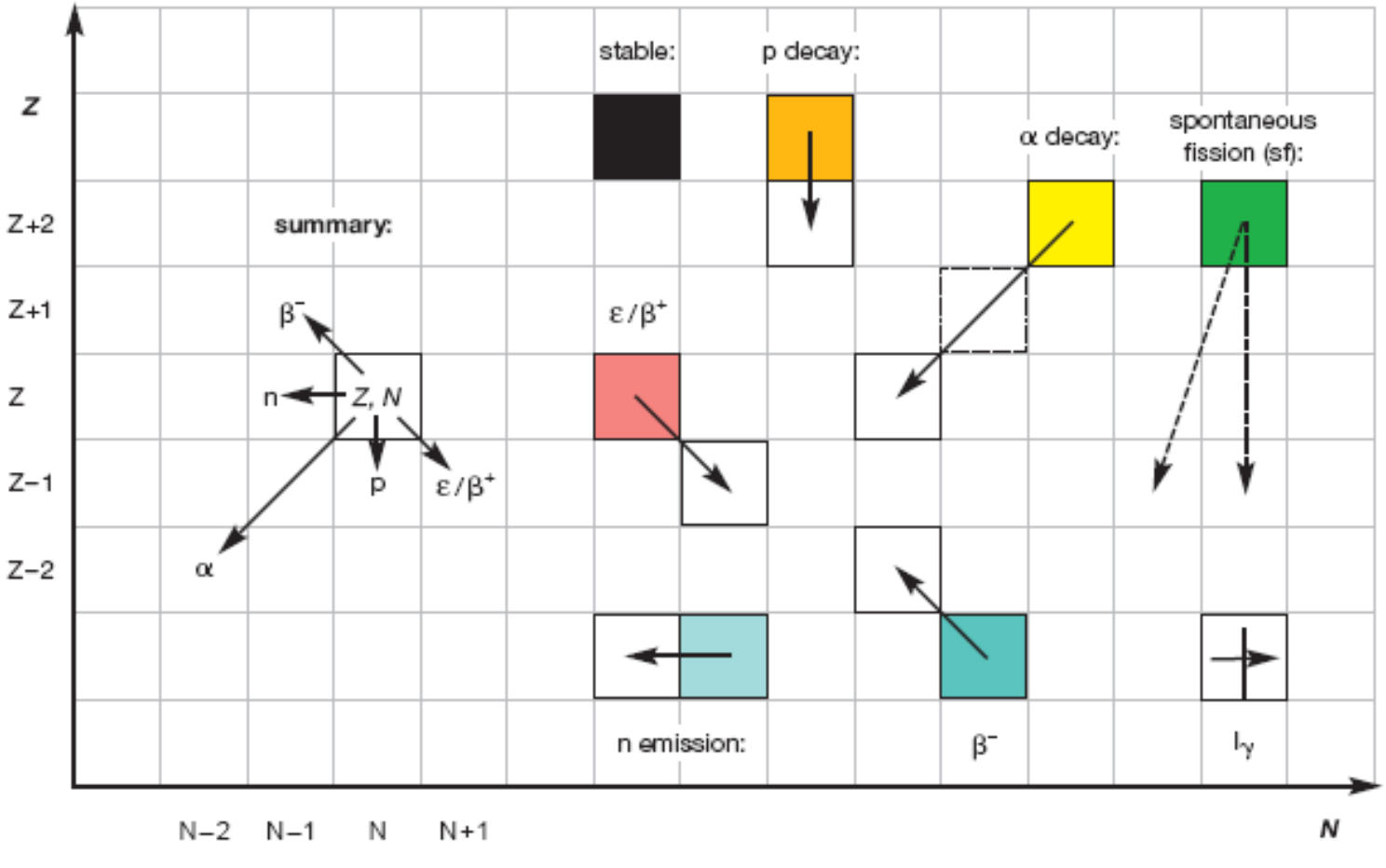
**Po 210**
138.38 d
α 5.30438...
γ (803)
σ < 0.0005 + < 0.030
$\sigma_{n,\alpha}$ 0.002
$\sigma_f$ < 0.1

**Cs 132**
6.47 d
ε, $\beta^+$...
$\beta^-$ 0.8...
γ 668, 465, 630..
$\sigma_{n,\alpha}$ < 0.15

**I 126**
13.11 d
ε
$\beta^-$ 0.9, 1.3...
$\beta^+$ 1.1...
γ 389, 666...
σ 5960



# Decay processes on the KNC



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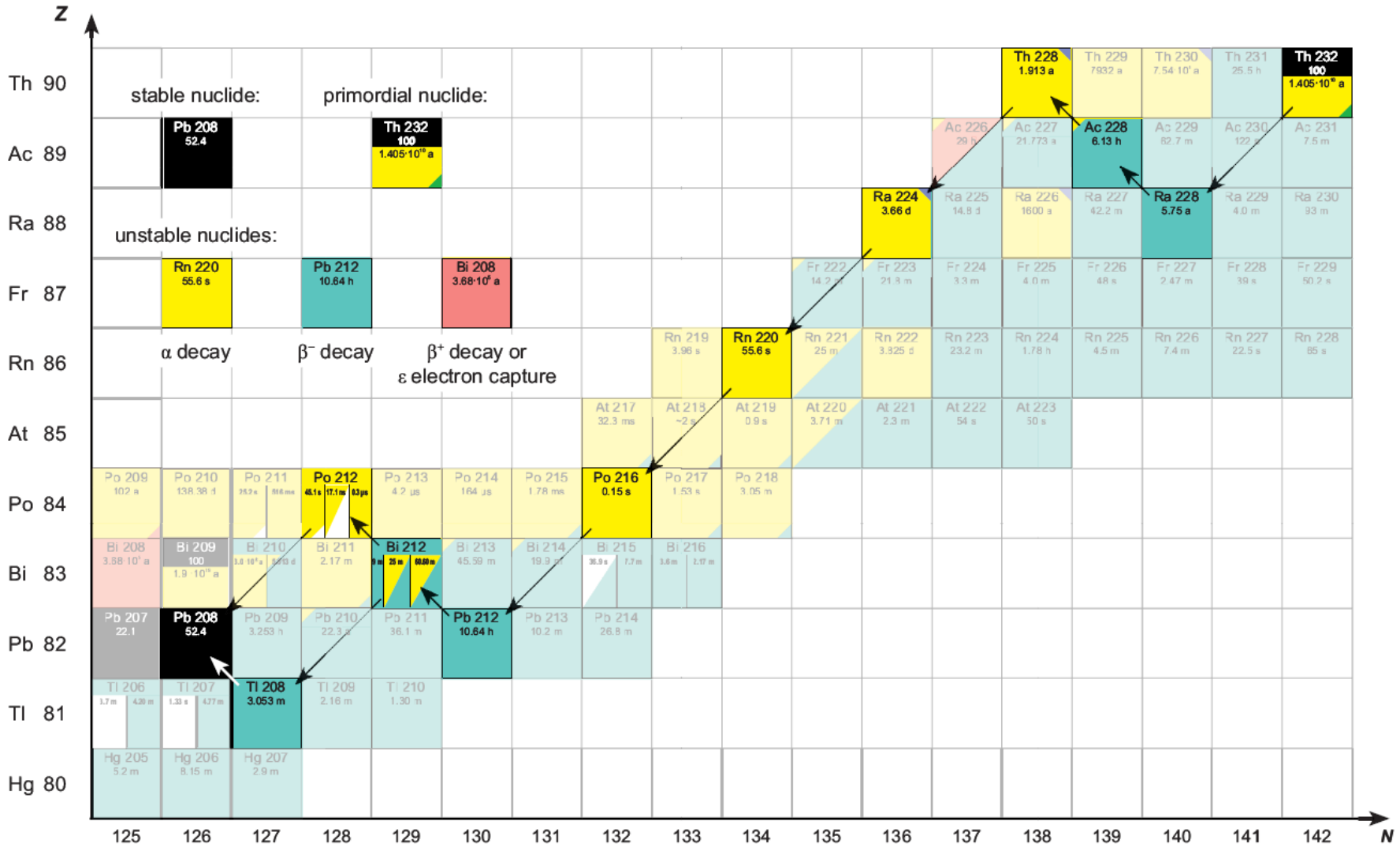


# Data in KNC boxes

**Elements**

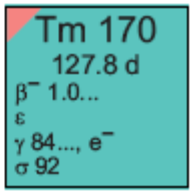
symbol of the element
standard atomic weight based on C 12 = 12

absorption cross section for thermal neutrons (barn)


**Unstable Nuclides**

symbol of the element, number of nucleons
half-life
modes of decay, endpoint energy of β⁻ radiation (MeV)

γ-energy (keV), conversion electrons,
(n, γ)-cross section (barn)




**Stable Nuclides**

symbol of the element, number of nucleons
abundance in naturally occuring element (atom %)

(n, γ)-cross sections for the formation of the metastable and the ground state of Te 127 by thermal neutrons (barn)


symbol of the element, number of nucleons
half-lives

both states decay by electron capture;
the metastable state decays to the ground state with a branching ratio for Iγ in the range 50 % – 95 %


symbol of the element, number of nucleons

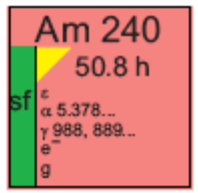
left hand side: half-life of metastable state;
γ-energy (keV) of the isomeric transition

right hand side: abundance in the natural element (atom %)
(n, γ)-cross section for the thermal neutrons (barn)


symbol of the element, number of nucleons

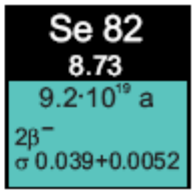
left hand side: spontaneous fission isomer, T < 0.1 s

right hand side: decay data of the ground state.
"g" indicates that the daughter Pu 240g is formed to at least 95 %; a population of Pu 240m up to 5 % cannot be excluded.



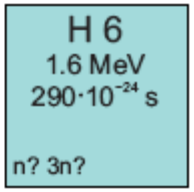

**Primordial radionuclides**

symbol of the element, number of nucleons
abundance in naturally occurring element (atom %)
half-life
double β decay
(n, γ) cross sections for the formation of the metastable and the ground state of Se 83 by thermal neutrons (barn)



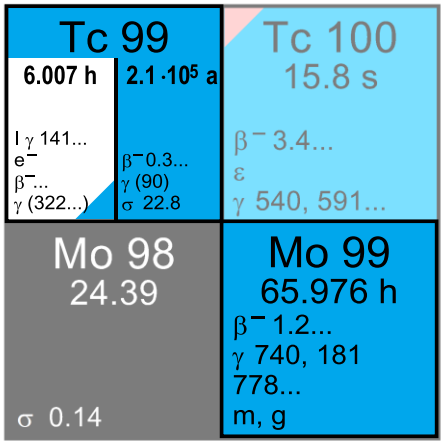

symbol of the element, number of nucleons

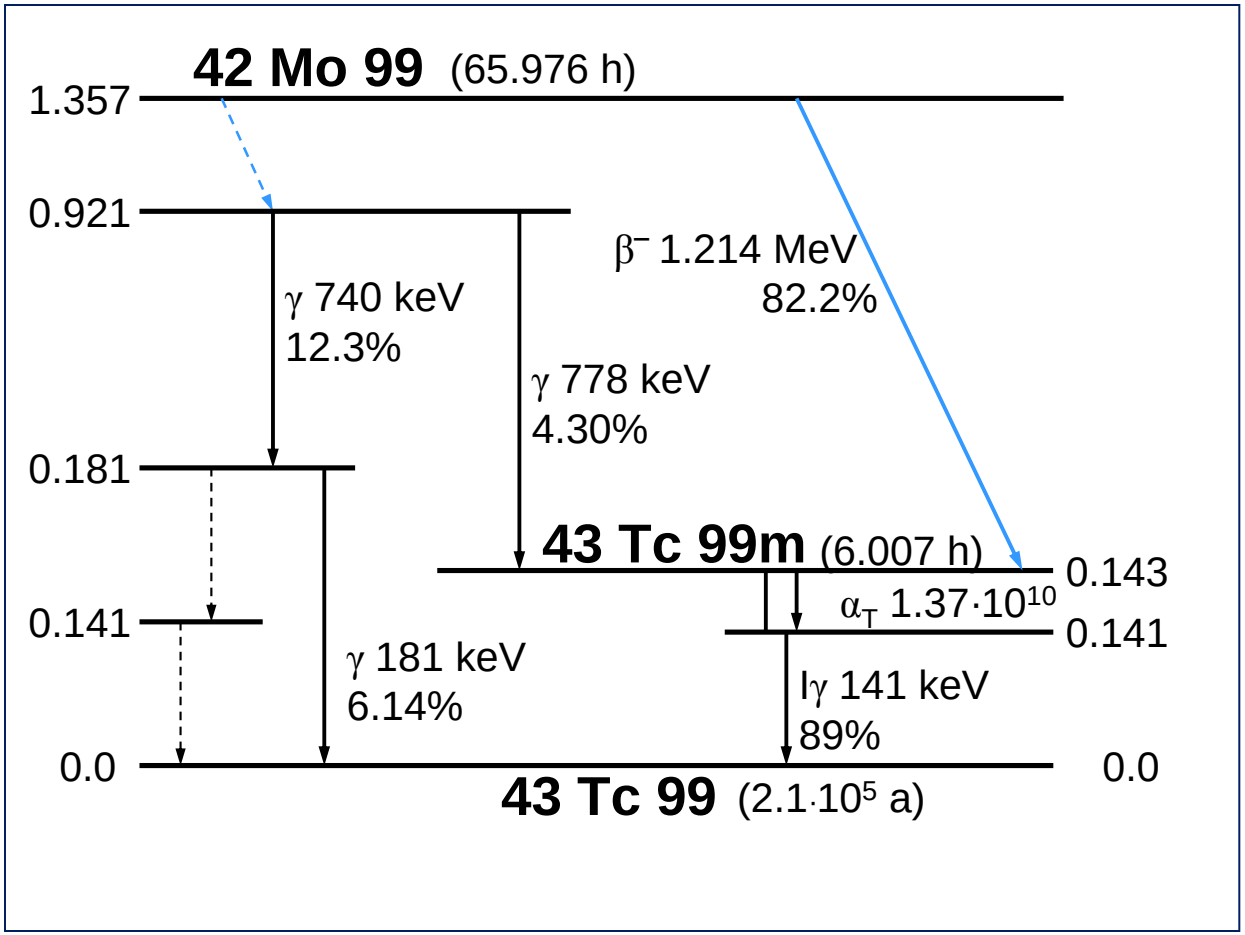
when emission of a particle results from a resonance state in an unstable nucleus, both the resonance width Γ (MeV) and the half-life $T_{1/2}$ are given



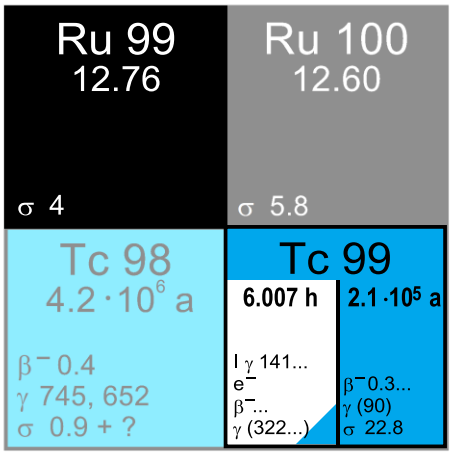

**KNC presents only experimentally observed nuclides**

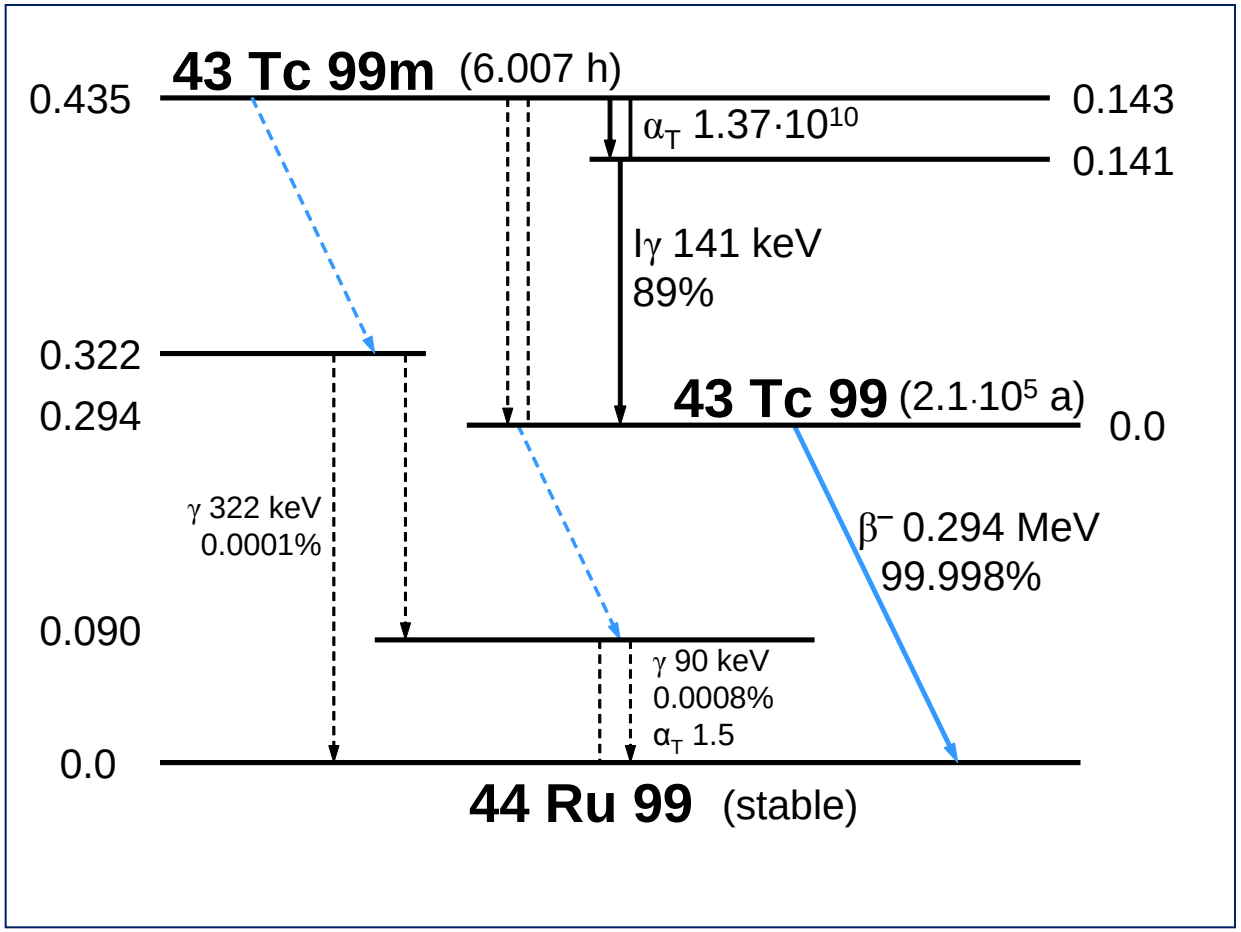
# Interpretation of condensed data radiation data



# Interpretation of condensed data radiation data

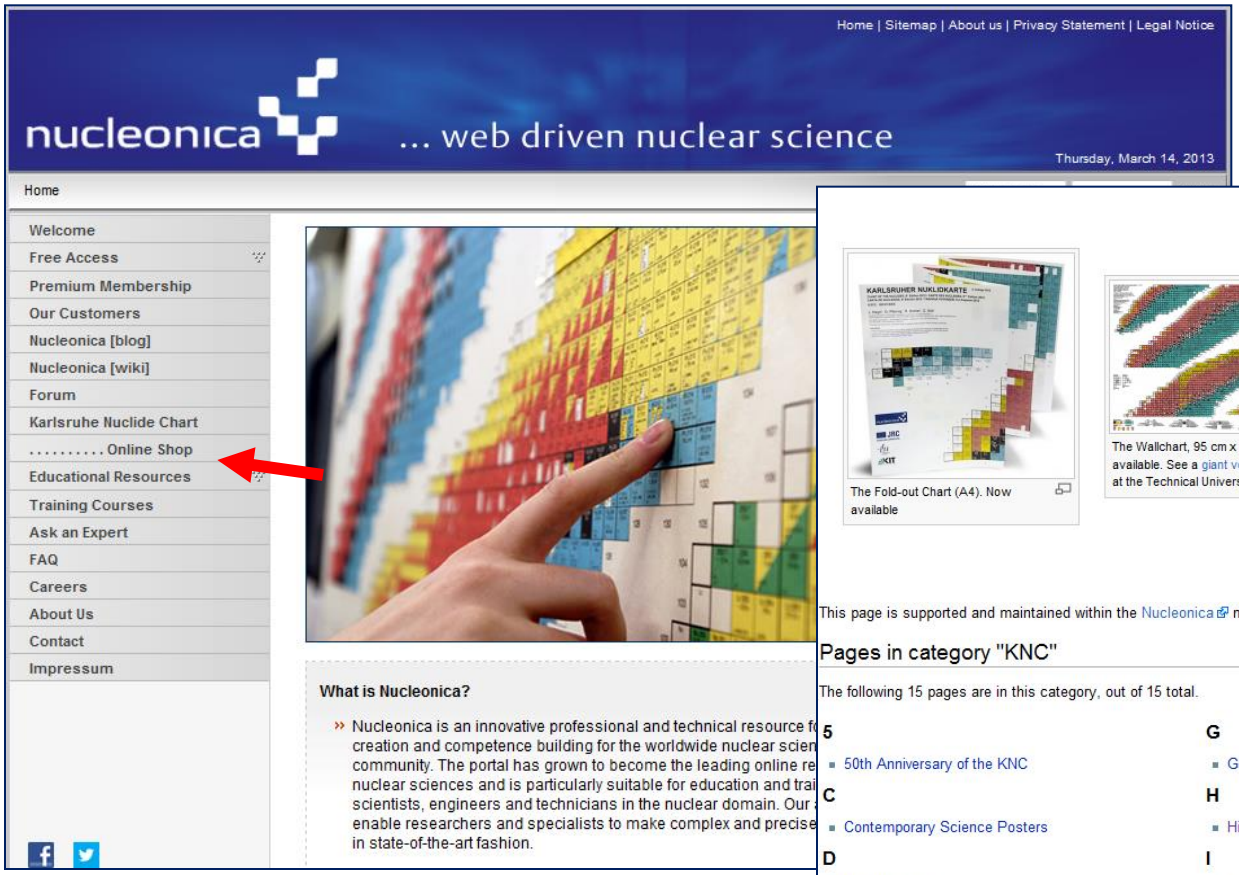


# Data sources

| Data | Sources used |
|---|---|
| | |
| **Half-lives**<br>**Branching ratios**<br>**Radiation data (particle and photon energies and emission probabilities)** | ENSDF, Nuclear Data Sheets (NDS) for evaluated nuclear data.<br>XUNDL database was the primary source of unevaluated nuclear data.<br>Nuclear Science References have been checked regularly based on the triggers from XUNDL database<br>Scientific journals (Physical Review C, Physics Letters B, The European Physical Journal A, Nuclear Physics A…) |
| **Cluster radioactivity** | R. Bonetti, A. Guglielmetti Cluster radioactivity: An overview after twenty years |
| **Thermal fission yields** | The thermal fission yields are based on IAEA report Handbook of Nuclear Data for Safeguards |
| **Abundancies** | Abundances of stable and primordial isotopes are presented based on Berglund et al. Isotopic composition of elements 2009 |
| **Cross Sections** | Handbook of Chemistry and Physics 2010 [23]. |
| **Data on fission isomers** | Half-lives of fission isomers in the brochure are based on the Nuclear Data Sheets Table of Superdeformed Nuclear Bands and Fission Isomer |
| **Atomic Weights** | The atomic weights of the elements are based on IUPAC Technical Report 2009 |
| **Periodic Table** | IUPAC Periodic Table of Elements |
| **Cross Sections** | Cross Sections are presented based on Holden: Handbook of Chemistry and Physics 2010 |
| **Element Properties (densities, etc.)** | Holden: Handbook of Chemistry and Physics 2010 |
| **Physical constants** | The Physical Constants presented in the brochure are based on CODATA Recommended Values 2010 |

# More info…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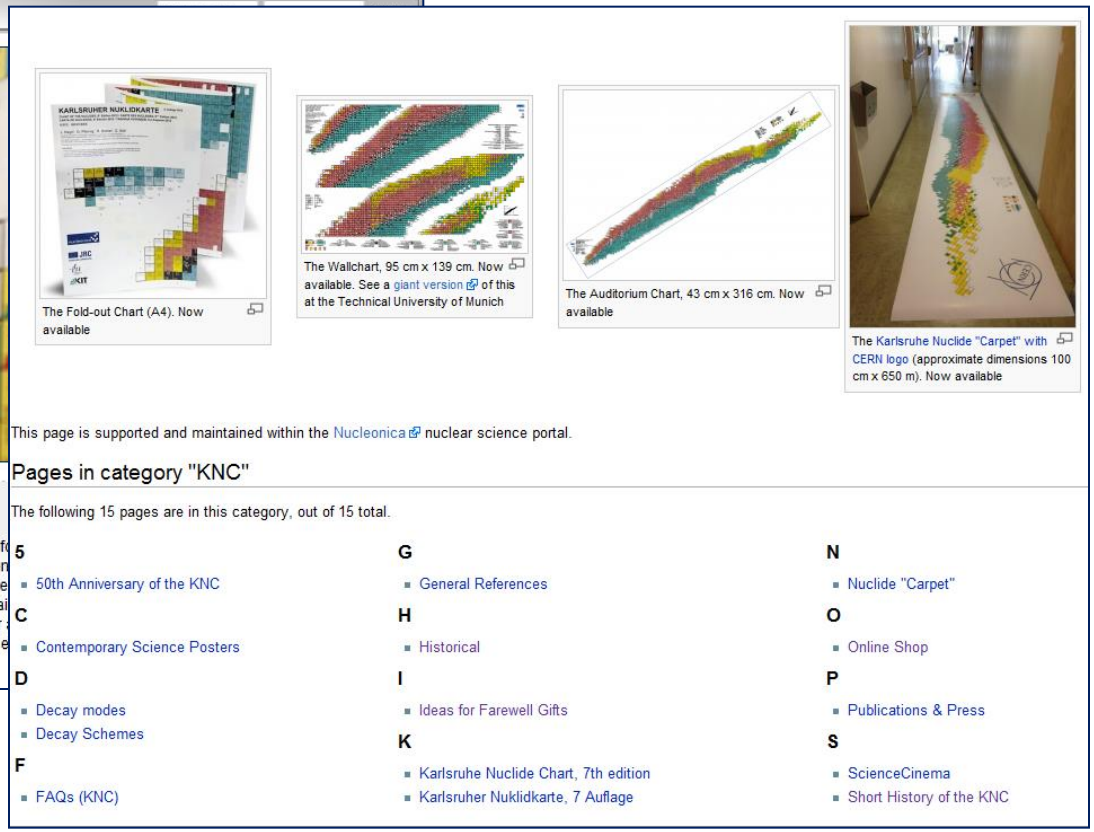
The Fold-out Chart (A4). Now available
The Wallchart, 95 cm x 139 cm. Now available. See a giant version of this at the Technical University of Munich
The Auditorium Chart, 43 cm x 316 cm. Now available
The Karlsruhe Nuclide "Carpet" with CERN logo (approximate dimensions 100 cm x 650 m). Now available
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The following 15 pages are in this category, out of 15 total.
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C
Contemporary Science Posters
D
Decay modes
Decay Schemes
F
FAQs (KNC)
G
General References
H
Historical
I
Ideas for Farewell Gifts
K
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N
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O
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S
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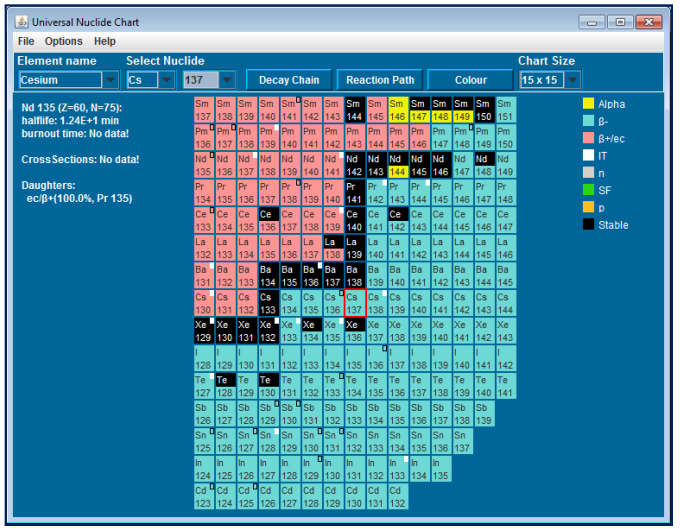
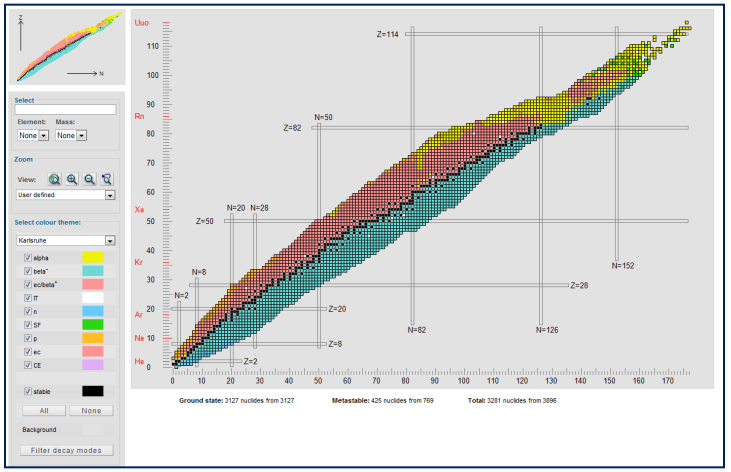
Short History of the KNC

# Electronic Nuclide Charts in Nucleonica

Universal Nuclide Chart
(UNC – decay chain simulator)




Nuclide Explorer
(connected with other
Nucleonica tools)



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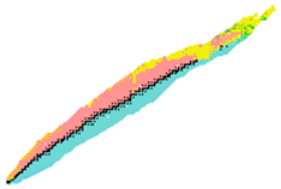
# Universal Nuclide Chart

› Nuclide Explorer



» Actual Chart: Karlsruhe

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- » New: Mass Activity Converter
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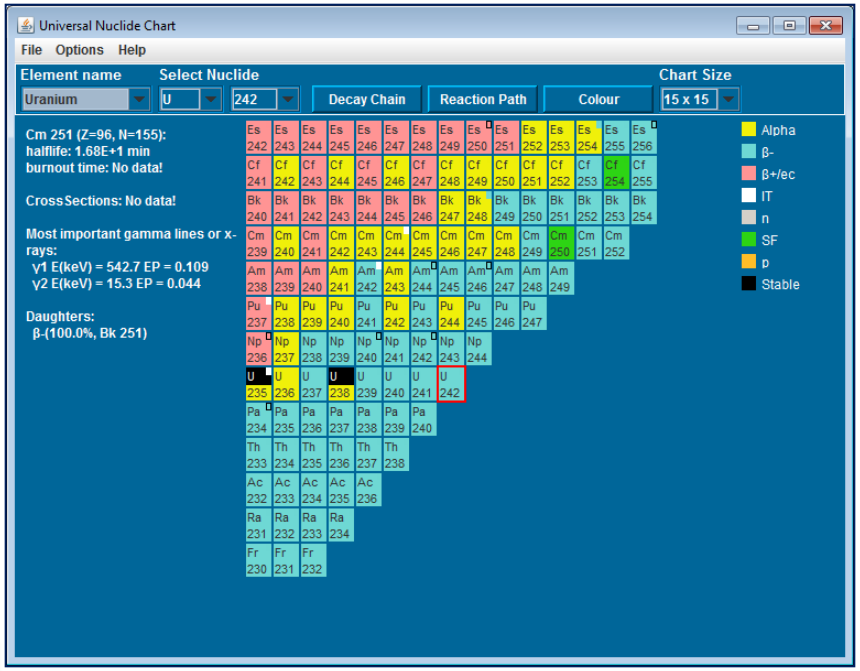
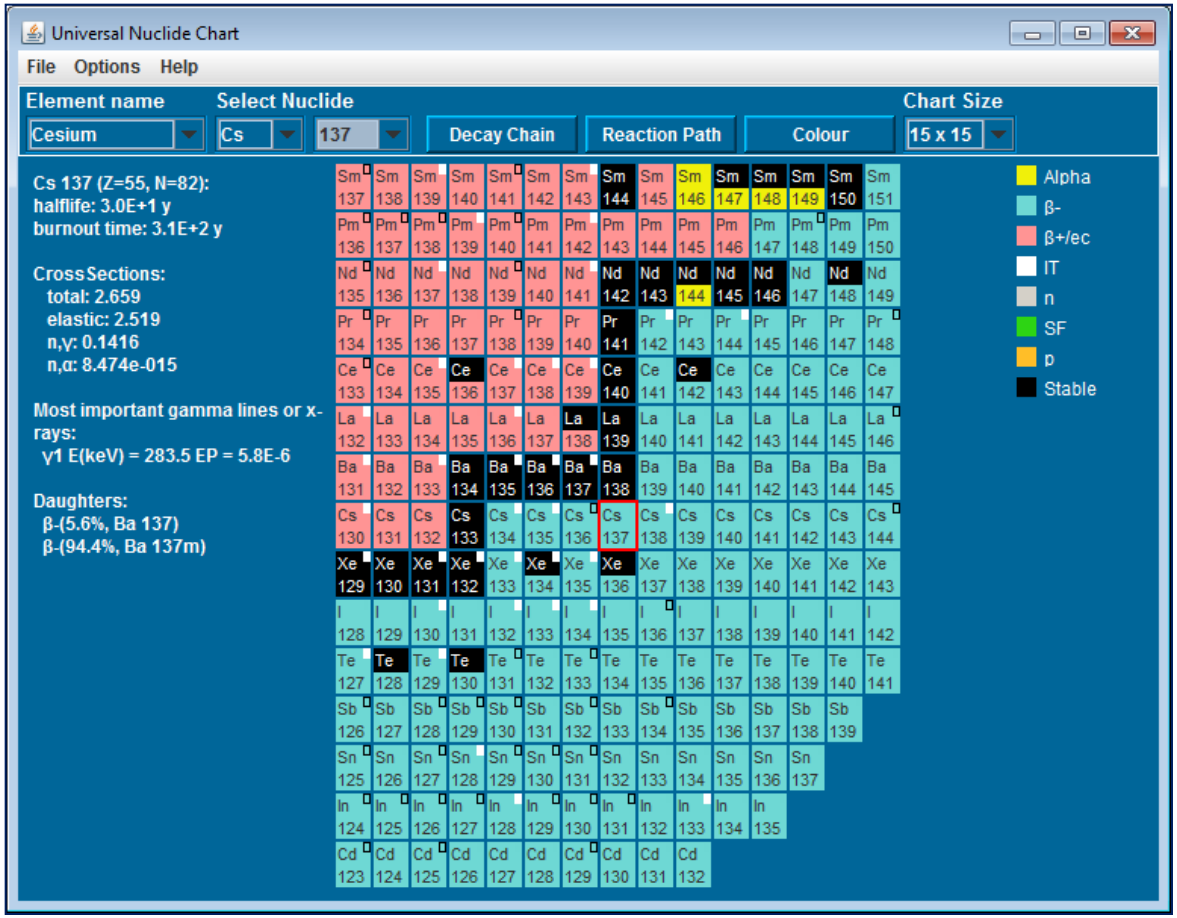
**Universal Nuclide Chart**

Click here to access the Universal Nuclide Chart

Applet



# Nuclear Data in UNC



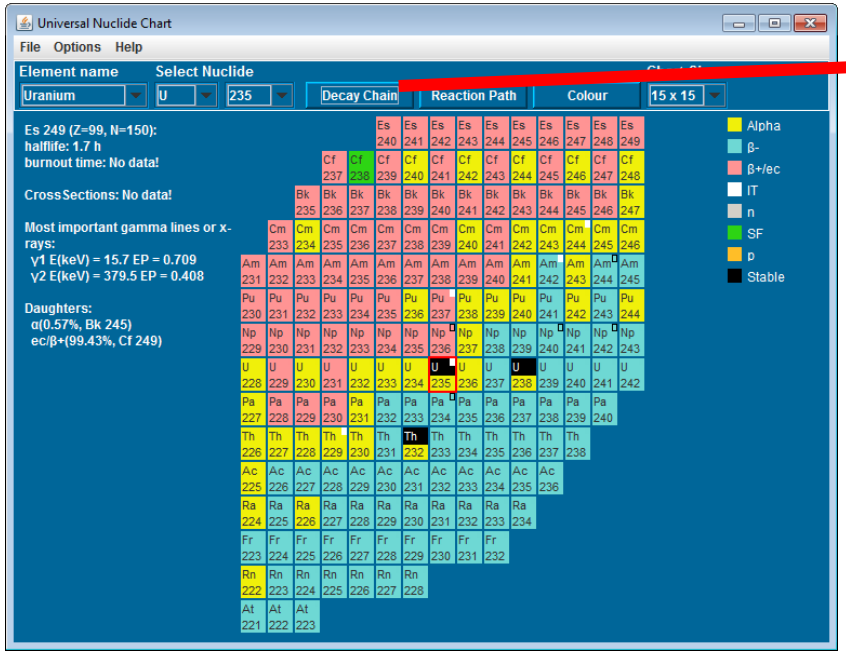

The Selected Nuclide
is in the middle of the Chart

Mouse pointer:
For the pointed nuclide
the most important
nuclear data is shown on
the left side

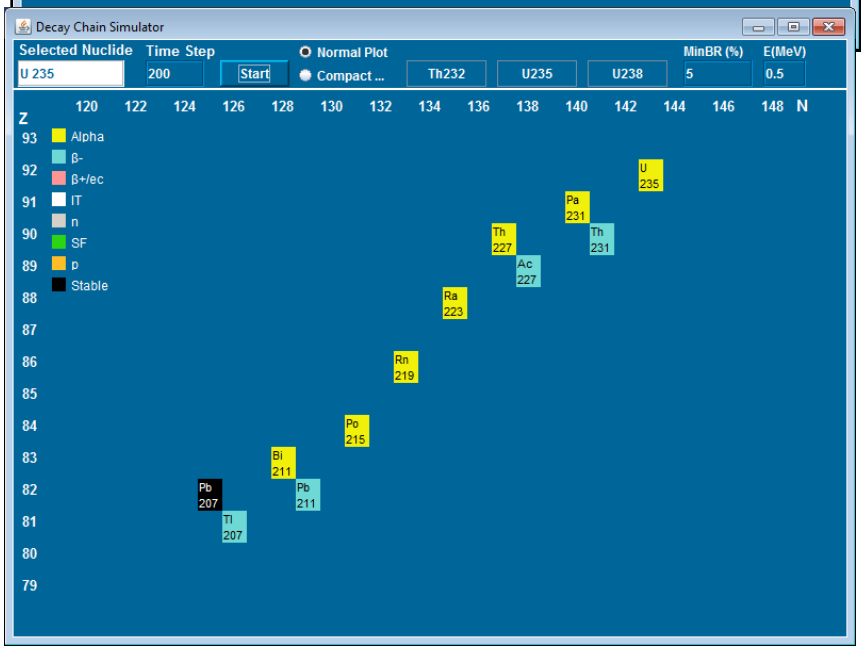
Decay Chain button

Reaction Path button

# Decay chain of U-235





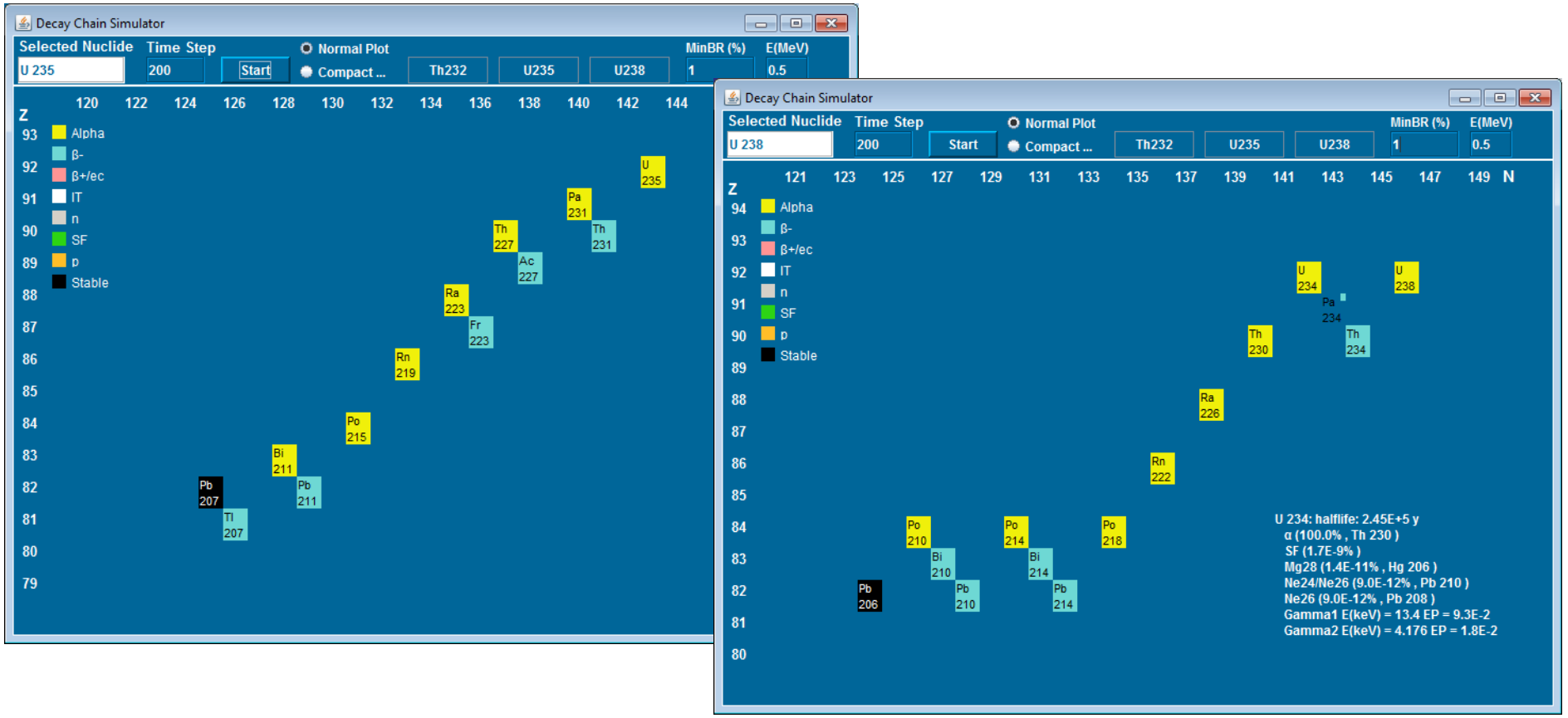



Set MinBr(%) to 5% some decay path are not displayed anymore

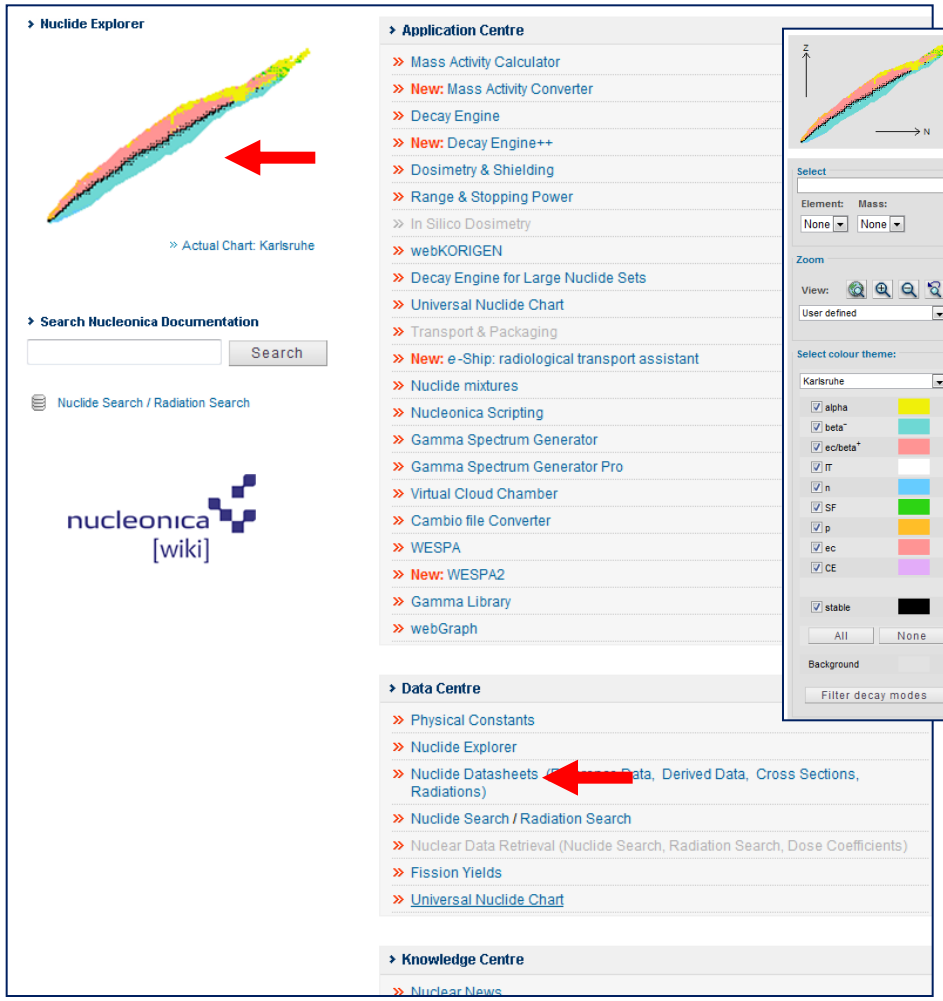
E(MeV): causes blinking alarm on nuclides with higher:
gamma energy * emission probability

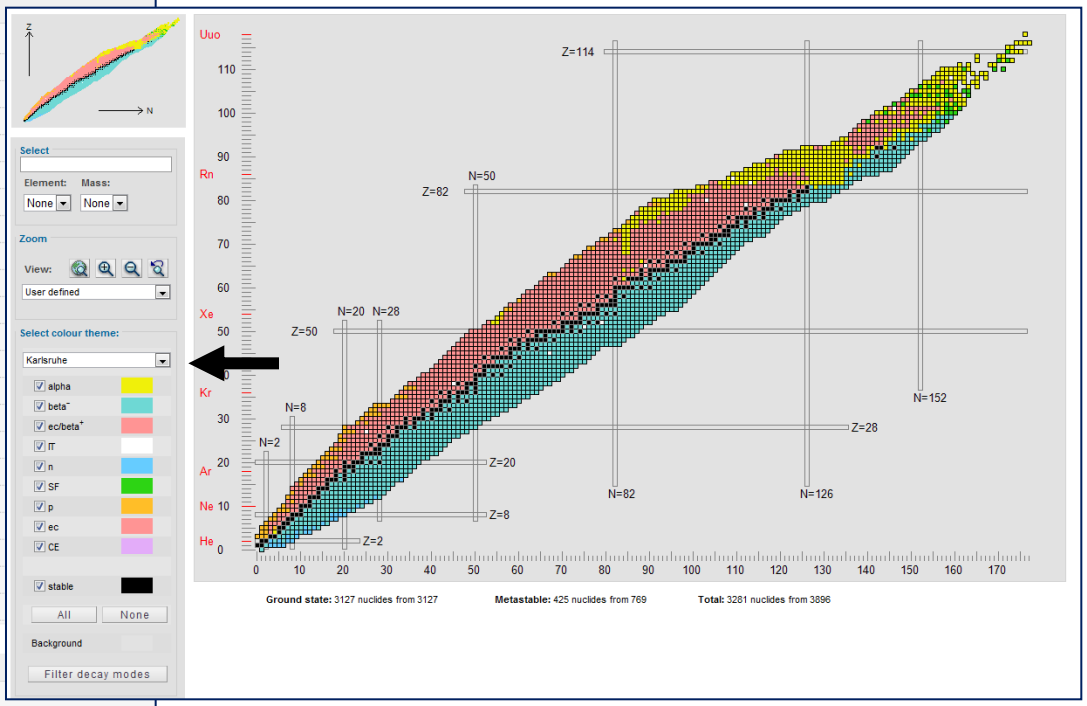
European Commission

# Decay chains of U-235 and U-238



# Nuclide Explorer



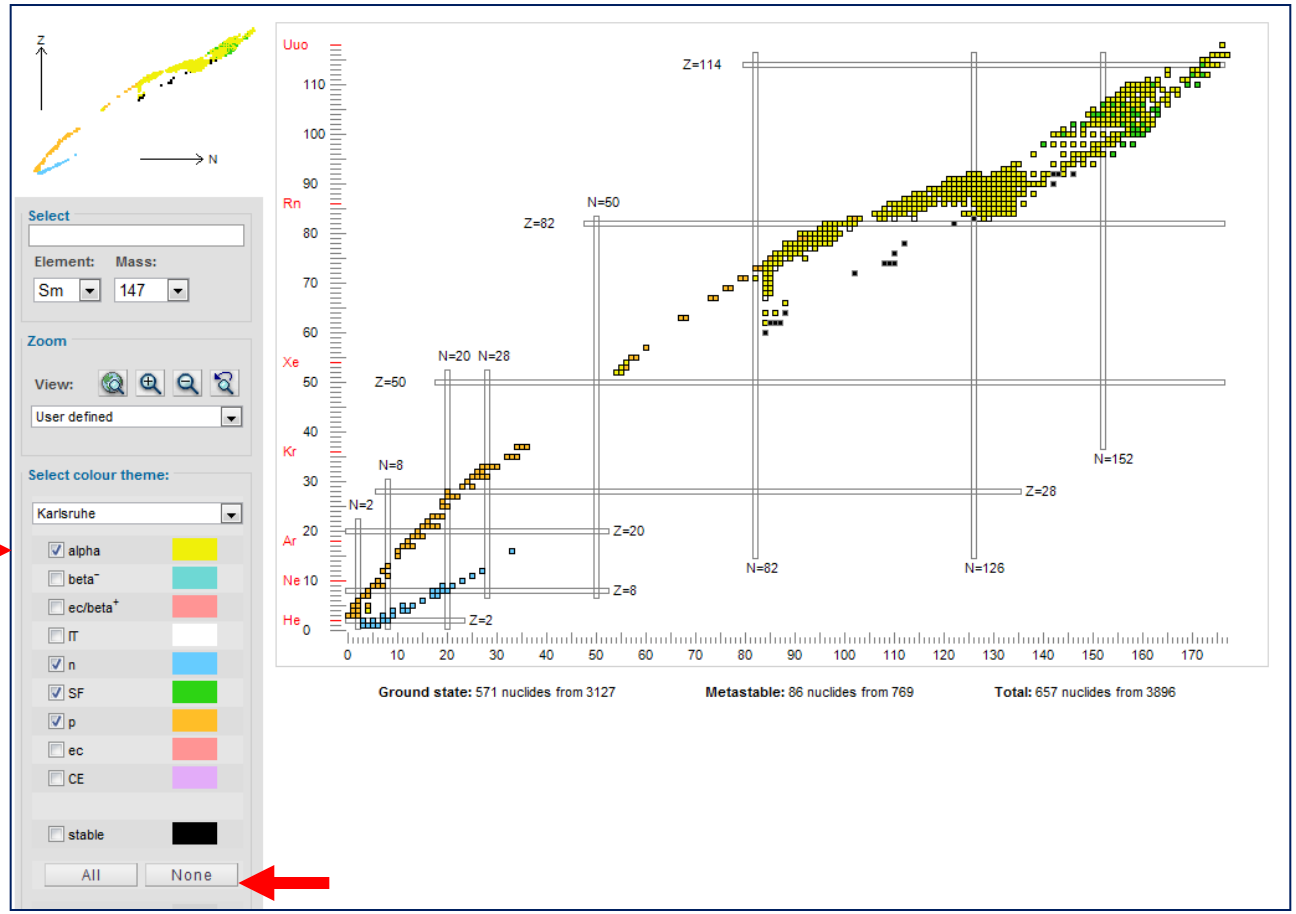




Colour scheme is changeable

Decay modes can be filtered

# Nuclide Tc-99m

# Nuclides with alpha, p and n main decay modes and SF nuclides



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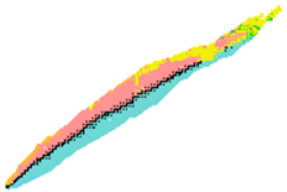
# Nuclear Data Sheets

› Nuclide Explorer



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Nuclide selector

Cs137
30.06 y

Version: 2013.03.08 13:28:50

**Nuclide Datasheets**

55 Cesium

Questions, remarks, suggestions can be posted in the forum

Current Chart: Karlsruhe

Element Cs Mass 137

Nuclide Explorer

Tabs

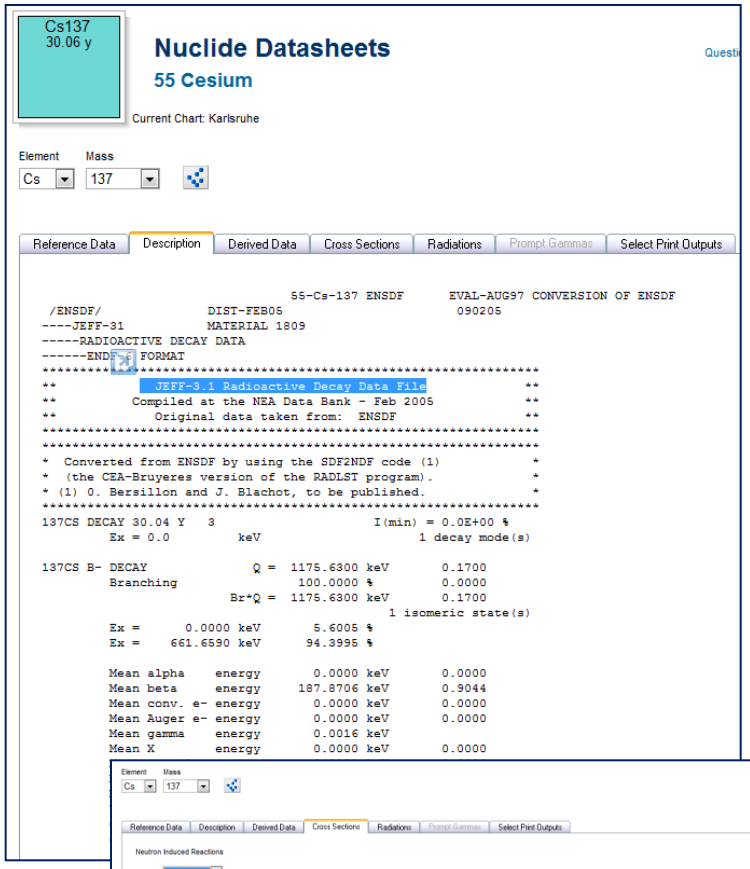
Reference Data | Description | Derived Data | Cross Sections | Radiations | Prompt Gammas | Select Print Outputs

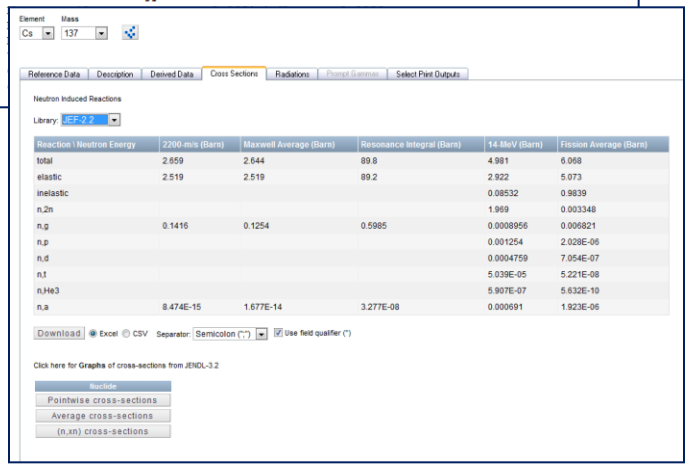
» Reference Data Notes

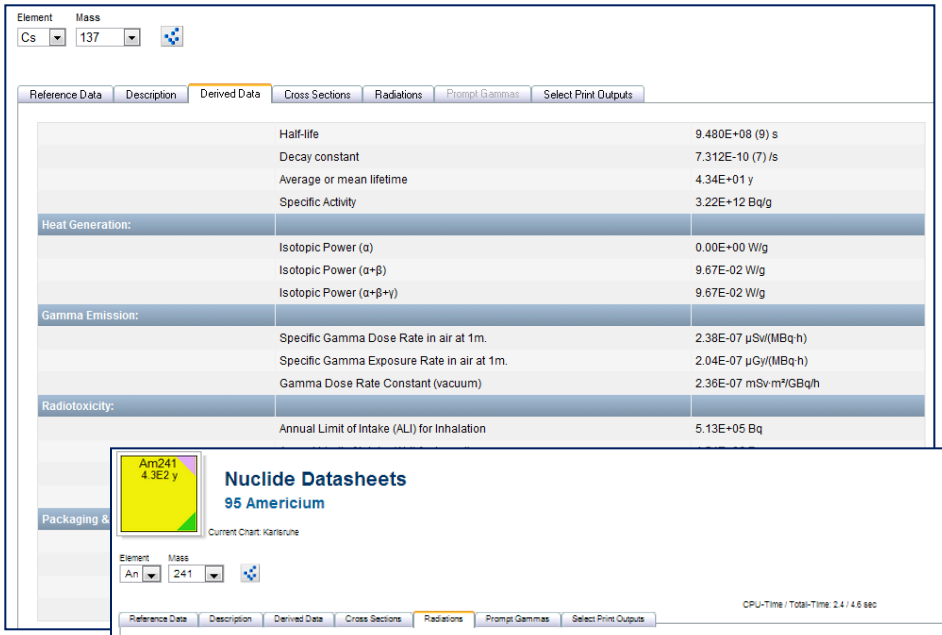
| | | | |
|---|---|---|---|
| **Nuclide** | $^{137}_{55}Cs_{82}$ | | |
| **Density** | 1.93 g/cm$^3$ | | |
| **Mass Excess** | -86545.599 (± 455) keV | | |
| **Atomic Mass** | 136.907089473 (± 487) u | | |
| **Half-life** | 30.04 (± 3) y | | |
| **Spin** | 7/2 ħ | | |
| **Parity** | + | | |
| **Binding Energy** | 8.38896 MeV/nucleon | | |
| **Abundance** | - | | |
| **Effective Dose Coefficient Inhalation** | 3.9E-08 (Sv/Bq) | | |
| **Effective Dose Coefficient Ingestion** | 1.3E-08 (Sv/Bq) | | |
| **Mean Decay Energies** | | | |
| **Alpha** | 0 (Mev) | | |
| **Electron** | 187.871 (keV) | | |
| **Photon** | 0.0016443 (keV) | | |
| **Type of decay** | **Branching Ratio** | **Decay Energy,Q** | **Daughters** |
| β- | 0.0560055 | 1.17563 (MeV) | 56 Ba 137 |
| β- | 0.943995 | 0.513971 (MeV) | 56 Ba 137m |
| **Type of parent decay** | **Branching Ratio** | **Decay Energy,Q** | **Parents** |
| β- | 1 | 4.172 (MeV) | 54 Xe 137 |

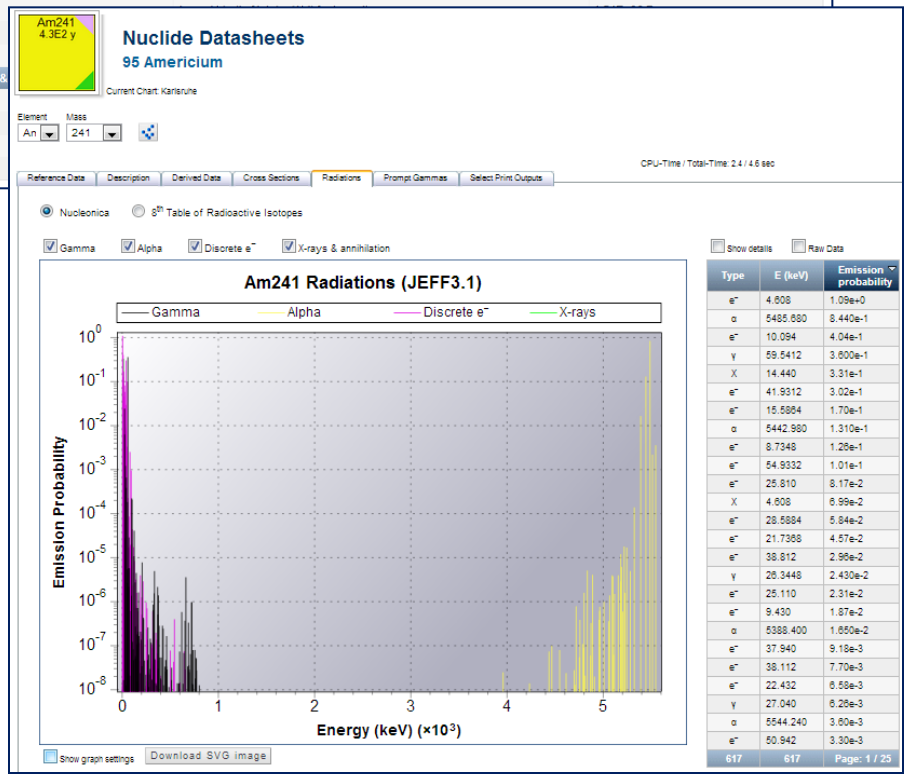
Download Excel CSV Separator: Semicolon (";") Use field qualifier (")

# Nuclear Data Sheets



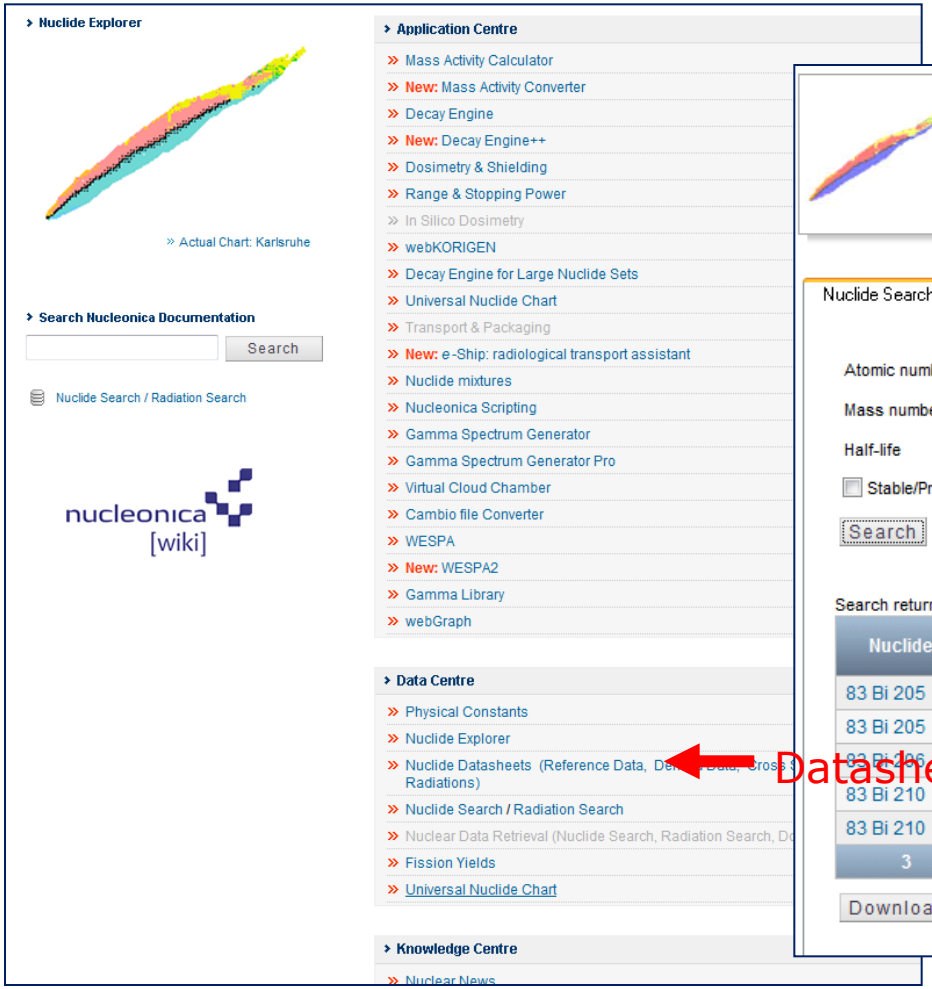



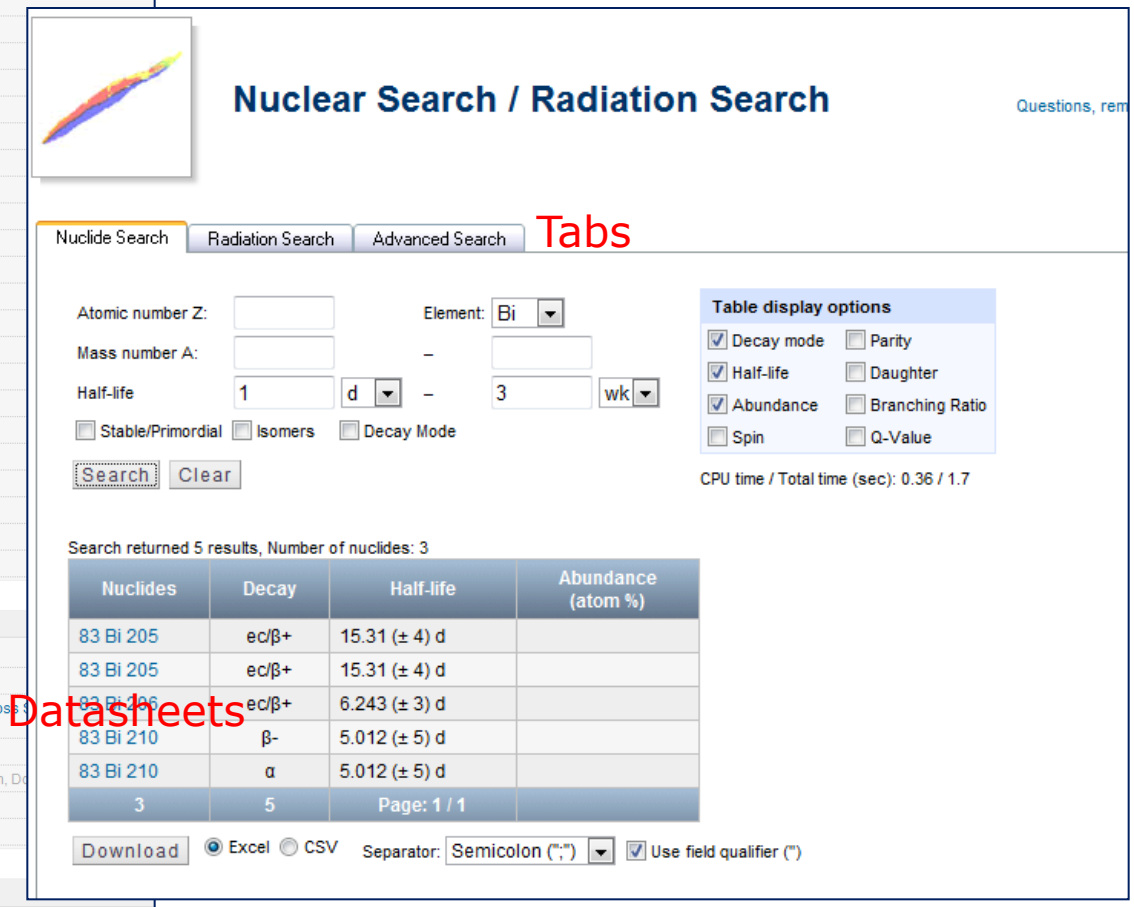



European Commission

# Nuclear Data Search

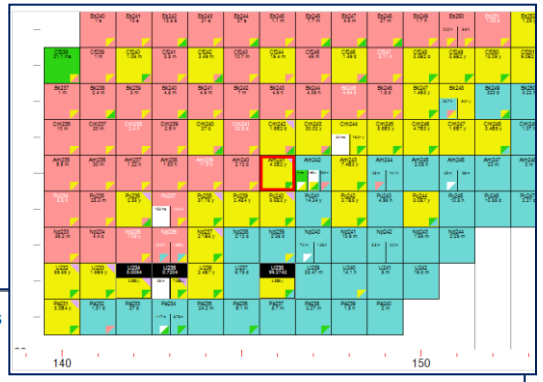



Datasheets

European Commission

# Radiation search



Nuclide Search | Radiation Search | Advanced Search

Gamma and X-Rays / Alpha

| | | | | |
|---|---|---|---|---|
| Energy: | 28 | +/- | 1 | keV |
| | 60 | +/- | 1.0 | keV |
| | 102 | +/- | 1 | keV |
| Emission probability: | | – | | |
| Atomic number Z: | | Element: | | |
| Mass number A: | | – | | |
| Half-life: | | s – | | s |

Table display options: Energy uncertainty; E.P. uncertainty; Half-life; FD

Search | Clear

CPU time / Total time (sec):

Search returned 19 results, Number of nuclides: 4

| Nuclides | Gamma and X-Rays (keV) | Emission Probability | Half-life |
|---|---|---|---|
| 95 Am 241 | 102.96 | 0.000209 | 432.8 (± 7) y |
| 91 Pa 231 | 102.85 | 0.00171 | 32.76 (± 11) ky |
| 91 Pa 231 | 102.8 | 0.00015 | 32.76 (± 11) ky |
| 91 Pa 231 | 102.1 | 0.000896 | 32.76 (± 11) ky |
| 91 Pa 228 | 102 | 0.00042 | 22 (± 1) h |
| 67 Ho 161 | 101.99 | 0.000156 | 2.48 (± 12) h |
| 95 Am 241 | 101.07 | 2.07E-05 | 432.8 (± 7) y |
| 91 Pa 231 | 60.5 | 5.5E-05 | 32.76 (± 11) ky |
| 91 Pa 228 | 60.3 | 9.7E-05 | 22 (± 1) h |
| 91 Pa 228 | 60.3 | 9.7E-05 | 22 (± 1) h |
| 91 Pa 228 | 59.8 | 2.8E-05 | 22 (± 1) h |
| 95 Am 241 | 59.5412 | 0.36 | 432.8 (± 7) y |
| 67 Ho 161 | 59.24 | 0.00605 | 2.48 (± 12) h |
| 91 Pa 228 | 28.8 | 0.000152 | 22 (± 1) h |
| 67 Ho 161 | 28.69 | 1.17E-05 | 2.48 (± 12) h |
| 95 Am 241 | 28.51 | 2.77E-05 | 432.8 (± 7) y |
| 91 Pa 228 | 28.3 | 2E-05 | 22 (± 1) h |
| 91 Pa 231 | 27.36 | 0.111 | 32.76 (± 11) ky |
| 95 Am 241 | 27.04 | 0.00626 | 432.8 (± 7) y |
| 4 | 19 | Page: 1 / 1 | |

Am241
4.3E2 y

**Nuclide Datasheets**

**95 Americium**

Current Chart: Karlsruhe

Element: Am | Mass: 241

Reference Data | Description | Derived Data | Cross Sections | Radiations | Prompt Gammas | Select Print Outputs

Nucleonica

Gamma Rays | Alpha Particles | Discrete Electrons | X-rays and Annihilation Radiation

Update | Show details

**Gamma Rays**

Number of lines: 185
Sum E.P (eV per disintegration): 2.24E+04

| Energy, E(keV) | Emission Probability, E.P. | αTotal | αK | αL |
|---|---|---|---|---|
| 59.5412 | 0.36 | 1.12 | 0 | 0.84 |
| 26.3448 | 0.0243 | 7.08 | 0 | 5.2 |
| 27.04 | 0.0063 | 4.03 | 0 | 2.98 |
| 33.1964 | 0.00122 | 188 | 0 | 140 |
| 43.42 | 0.00066 | 169 | 0 | 124 |
| 42.72 | 0.00039 | 80 | 0 | 60 |
| 98.97 | 0.000223 | 15.6 | 0 | 11.3 |
| 102.96 | 0.000209 | 0.121 | 0 | 0.091 |
| 55.55 | 0.00018 | 68 | 0 | 50 |
| 125.31 | 4.1E-05 | 0.304 | 0.232 | 0.055 |
| 69.76 | 2.9E-05 | 0.336 | 0 | 0.252 |
| 28.51 | 2.8E-05 | 3.51 | 0 | 2.6 |
| 123 | 1.08E-05 | 5.9 | 0.2 | 4.1 |
| 208 | 7.8E-06 | 3.23 | 2.56 | 0.51 |
| 75.92 | 5.8E-06 | 54.2 | 0 | 39.3 |
| 64.82 | 5.8E-06 | 0.408 | 0 | 0.305 |
| 51.01 | 5.4E-06 | 0.77 | 0 | 0.57 |
| 335.39 | 4.97E-06 | 0.747 | 0.586 | 0.121 |

# Dose Coefficients (ICRP 68 & 72)

**ICRP Database Search**

Dose coefficient quick link

| Data source | Type | Element(s) | |
|---|---|---|---|
| ☑ ICRP 68 | ☑ Ingestion | ◉ Element | Pu |
| ☑ ICRP 72 | ☑ Inhalation | ○ All | |

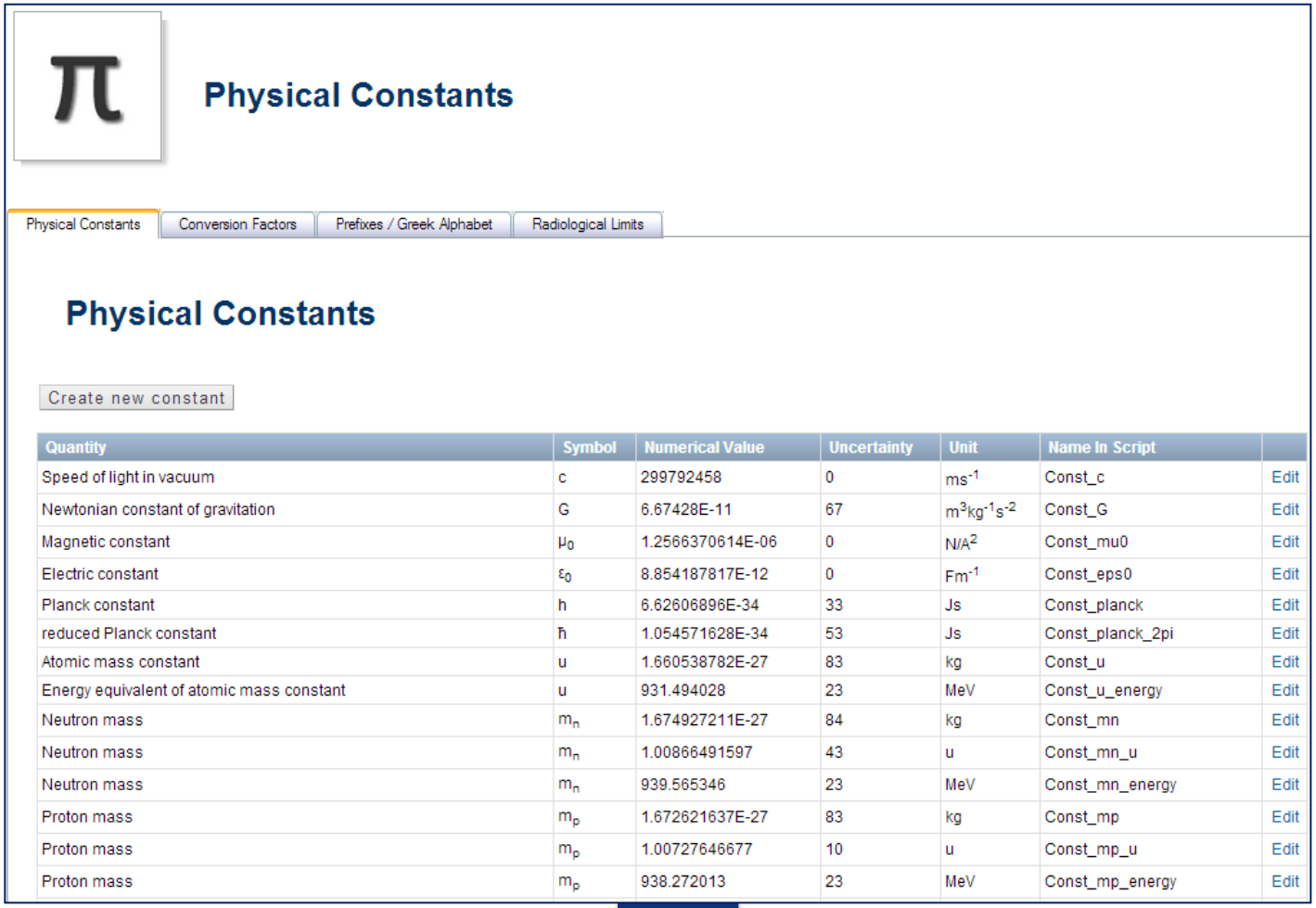
Search | Save as my default

Search returned 13 results

| Nuclides | ICRP 68: Effective dose coefficient (inhalation) $e(50)_{inh}$ (Sv/Bq) | ICRP 68: Effective dose coefficient (ingestion) $e(50)_{ing}$ (Sv/Bq) | ICRP 72: Effective dose coefficient (inhalation) $e(50)_{inh}$ (Sv/Bq) | ICRP 72: Effective dose coefficient (ingestion) $e(50)_{ing}$ (Sv/Bq) |
|---|---|---|---|---|
| 94 Pu 234 | 2.20E-08 | 1.60E-10 | 2.40E-08 | 1.60E-10 |
| 94 Pu 235 | 2.60E-12 | 2.10E-12 | 1.50E-12 | 2.10E-12 |
| 94 Pu 236 | 1.80E-05 | 8.60E-08 | 1.00E-05 | 8.70E-08 |
| 94 Pu 237 | 3.60E-10 | 1.00E-10 | 3.90E-10 | 1.00E-10 |
| 94 Pu 238 | 4.30E-05 | 2.30E-07 | 1.10E-04 | 2.30E-07 |
| 94 Pu 239 | 4.70E-05 | 2.50E-07 | 1.20E-04 | 2.50E-07 |
| 94 Pu 240 | 4.70E-05 | 2.50E-07 | 1.20E-04 | 2.50E-07 |
| 94 Pu 241 | 8.50E-07 | 4.70E-09 | 2.30E-06 | 4.80E-09 |
| 94 Pu 242 | 4.40E-05 | 2.40E-07 | 1.10E-04 | 2.40E-07 |
| 94 Pu 243 | 1.10E-10 | 8.50E-11 | 8.60E-11 | 8.50E-11 |
| 94 Pu 244 | 4.40E-05 | 2.40E-07 | 1.10E-04 | 2.40E-07 |
| 94 Pu 245 | 6.50E-10 | 7.20E-10 | 4.30E-10 | 7.20E-10 |
| 94 Pu 246 | 7.60E-09 | 3.30E-09 | 8.00E-09 | 3.30E-09 |

Download ◉ Excel ○ CSV Separator: Semicolon (";") ☑ Use field qualifier (")

# Physical Constants, Conversion Factors, Radiological limits…



## Physical Constants

Physical Constants | Conversion Factors | Prefixes / Greek Alphabet | Radiological Limits

### Physical Constants

Create new constant

| Quantity | Symbol | Numerical Value | Uncertainty | Unit | Name In Script | |
|---|---|---|---|---|---|---|
| Speed of light in vacuum | c | 299792458 | 0 | $ms^{-1}$ | Const_c | Edit |
| Newtonian constant of gravitation | G | 6.67428E-11 | 67 | $m^3kg^{-1}s^{-2}$ | Const_G | Edit |
| Magnetic constant | $\mu_0$ | 1.2566370614E-06 | 0 | $N/A^2$ | Const_mu0 | Edit |
| Electric constant | $\varepsilon_0$ | 8.854187817E-12 | 0 | $Fm^{-1}$ | Const_eps0 | Edit |
| Planck constant | h | 6.62606896E-34 | 33 | Js | Const_planck | Edit |
| reduced Planck constant | $\hbar$ | 1.054571628E-34 | 53 | Js | Const_planck_2pi | Edit |
| Atomic mass constant | u | 1.660538782E-27 | 83 | kg | Const_u | Edit |
| Energy equivalent of atomic mass constant | u | 931.494028 | 23 | MeV | Const_u_energy | Edit |
| Neutron mass | $m_n$ | 1.674927211E-27 | 84 | kg | Const_mn | Edit |
| Neutron mass | $m_n$ | 1.00866491597 | 43 | u | Const_mn_u | Edit |
| Neutron mass | $m_n$ | 939.565346 | 23 | MeV | Const_mn_energy | Edit |
| Proton mass | $m_p$ | 1.672621637E-27 | 83 | kg | Const_mp | Edit |
| Proton mass | $m_p$ | 1.00727646677 | 10 | u | Const_mp_u | Edit |
| Proton mass | $m_p$ | 938.272013 | 23 | MeV | Const_mp_energy | Edit |

# Physical Constants, Conversion Factors, Radiological limits…

## Physical Constants

Physical Constants | Conversion Factors | Prefixes / Greek Alphabet | Radiological Limits

## Radiological Limits

Workers | Apprentices and Students | Members of the Public

### Workers

| Dose Limits for exposed workers | Euratom | ICRP | IAEA | Germany |
|---|---|---|---|---|
| Limit on effective dose for exposed workers in a consecutive 5 years period: | 100 mSv | 20 mSv/y | 20 mSv/y | 20 mSv/y |
| Maximum effective dose in any single year: | 50 mSv/y | 50 mSv/y | 50 mSv/y | 50 mSv/y |
| Equivalent dose limit to the foetus, accumulated over the period of time between declaration of pregnancy to the delivery date: | 1 mSv | 2 mSv | | 1 mSv |
| Pregnant woman | | | | 2 mSv/m |
| Total work life (50 y) | | | | 400 mSv |
| ***Partial body exposure:*** | | | | |
| Limit on equivalent dose for the lens of the eyes: | 150 mSv/y | 150 mSv/y | 150 mSv/y | 150 mSv/y |
| Limit on equivalent dose for the skin: | 500 mSv/y | 500 mSv/y | 500 mSv/y | 500 mSv/y |
| Limit on equivalent dose for the hands, forearms, feet and ankles: | 500 mSv/y | 500 mSv/y | 500 mSv/y | 500 mSv/y |

# Fission Yields

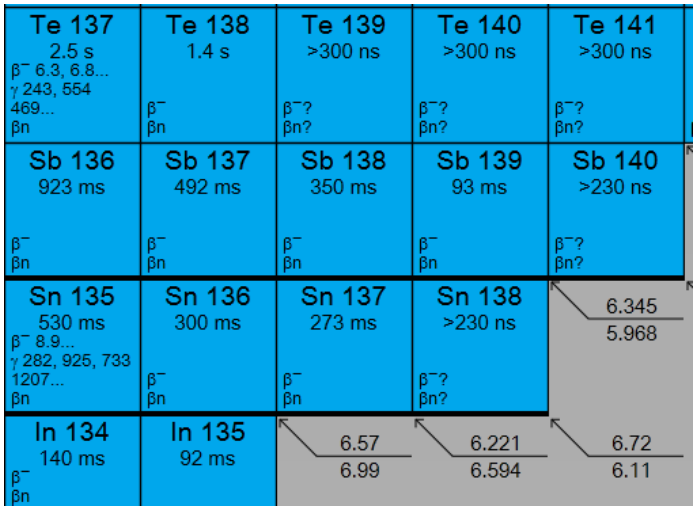
Fission Yield: Number of atoms of a specific nuclide produced per 100 fission reactions

Independent Fission Yields: direct production of specific atoms - decay excluded

Cumulative Fission Yields: direct production + via decay

Chain Yield: Atoms of specific isobars (A=const) per 100 fission reactions

(KNC: U-235 and Pu-239 yields)



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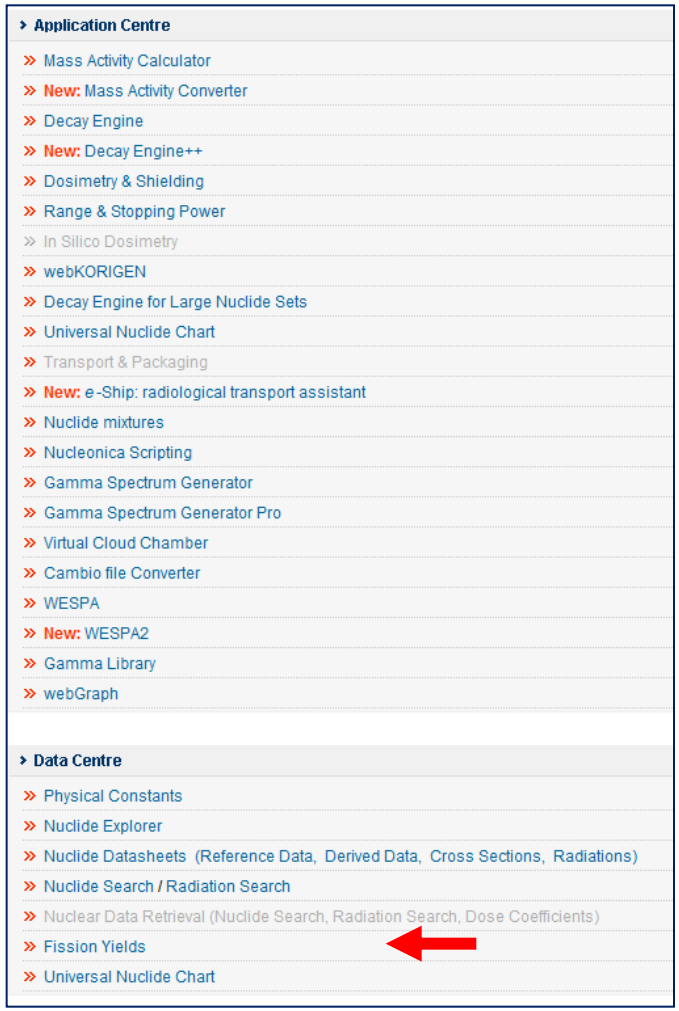
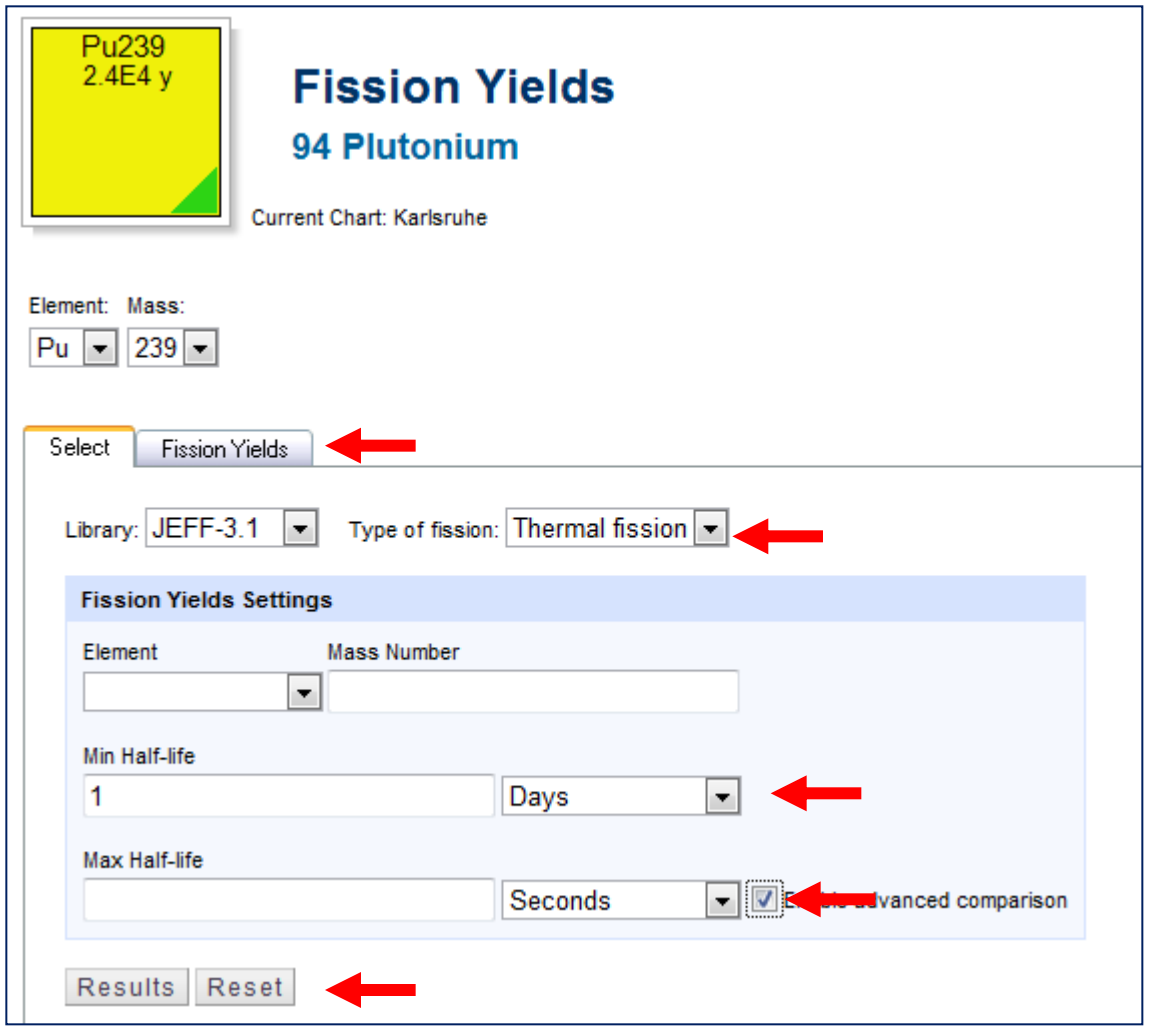
# Fission Yields Module

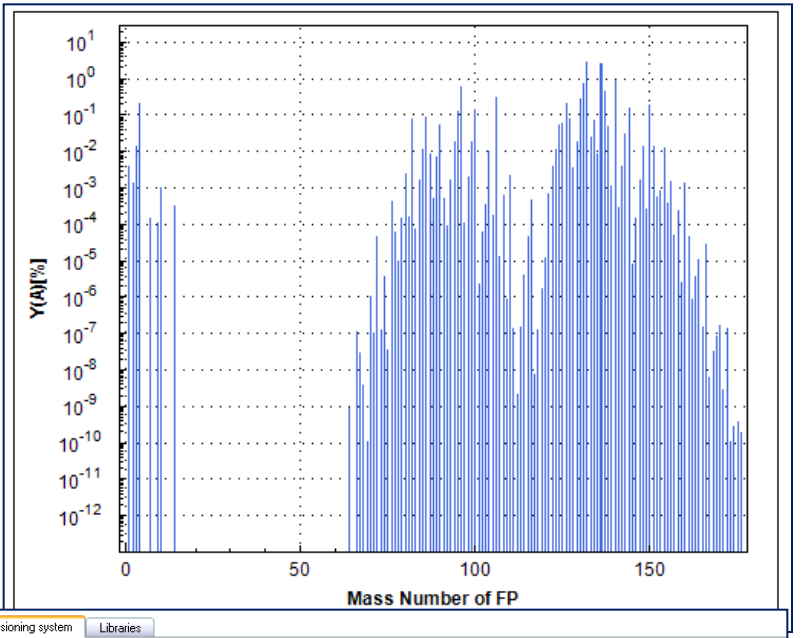


# Fission products of Pu-239

Total number of fission products: 306

| | Nuclide | Half-life | Independent Yield | Error | Cumulative Yield | Error |
|---|---|---|---|---|---|---|
| Compare | 52 Te 132 | 3.204 (± 13) d | 2.94E-02 | 4.47E-03 | 5.09E-02 | 9.36E-04 |
| Compare | 54 Xe 136 | 2.10E+20 (± 0) y | 2.70E-02 | 5.72E-03 | 6.90E-02 | 2.53E-03 |
| Compare | 56 Ba 140 | 12.765 (± 15) d | 8.76E-03 | 2.84E-03 | 5.32E-02 | 5.86E-04 |
| Compare | 52 Te 131m | 1.250 (± 8) d | 6.85E-03 | 1.89E-03 | 9.04E-03 | 1.45E-03 |
| Compare | 40 Zr 96 | 3.9E+19 (± 9) y | 5.82E-03 | 1.98E-03 | 4.93E-02 | 1.53E-03 |
| Compare | 55 Cs 137 | 30.04 (± 3) y | 4.57E-03 | 1.62E-03 | 6.59E-02 | 8.03E-04 |
| Compare | 44 Ru 106 | 1.020 (± 2) y | 2.98E-03 | 1.04E-03 | 4.19E-02 | 9.21E-04 |
| Compare | 52 Te 130 | 7.90E+23 (± 100) y | 2.68E-03 | 7.95E-04 | 2.79E-02 | 6.70E-03 |
| Compare | 2 He 4 | Stable | 2.19E-03 | 1.18E-04 | 2.19E-03 | 8.98E-05 |
| Compare | 50 Sn 126 | 230 (± 14) ky | 2.02E-03 | 3.86E-04 | 2.64E-03 | 4.71E-04 |
| Compare | 60 Nd 150 | 2.1E+19 (± 5) y | 1.87E-03 | 5.22E-04 | 9.75E-03 | 1.27E-04 |
| Compare | 58 Ce 144 | 285.0 (± 2) d | 1.63E-03 | 6.02E-04 | 3.75E-02 | 3.00E-04 |
| Compare | 42 Mo 100 | 9.9E+18 (± 7) y | 1.44E-03 | 5.72E-04 | 6.84E-02 | 9.98E-03 |
| Compare | 40 Zr 95 | 64.032 (± 6) d | 1.33E-03 | 4.84E-04 | 4.95E-02 | 9.90E-04 |
| Compare | 36 Kr 86 | Stable | 9.19E-04 | 3.01E-04 | 7.83E-03 | 1.85E-04 |
| Compare | 34 Se 82 | 1.21E+20 (± 17) y | 8.29E-04 | 2.30E-04 | 2.31E-03 | 4.11E-04 |
| Compare | 51 Sb 127 | 3.85 (± 5) d | 7.72E-04 | 2.50E-04 | 4.60E-03 | 2.67E-04 |
| Compare | 54 Xe 134 | 1.1E+16 (± 0) y | 6.79E-04 | 2.40E-04 | 6.87E-02 | 3.57E-03 |
| Compare | 55 Cs 136 | 13.03 (± 7) d | 5.88E-04 | 2.07E-04 | 7.60E-04 | 2.15E-04 |
| Compare | 38 Sr 90 | 28.79 (± 6) y | 5.66E-04 | 2.07E-04 | 2.01E-02 | 5. |
| Compare | 50 Sn 124 | 1.00E+17 (± 0) y | 5.09E-04 | 1.25E-04 | 1.26E-03 | 6. |
| Compare | 50 Sn 125 | 9.64 (± 3) d | 4.99E-04 | 9.46E-05 | 5.46E-04 | 8. |
| Compare | 56 Ba 138 | Stable | 4.70E-04 | 1.77E-04 | 6.11E-02 | 1. |
| Compare | 58 Ce 143 | 1.379 (± 2) d | 3.09E-04 | 1.15E-04 | 4.48E-02 | 4. |
| Compare | 53 I 131 | 8.0233 (± 19) d | 2.34E-04 | 8.14E-05 | 3.72E-02 | 7. |
| Compare | 40 Zr 94 | 6.0E+15 (± 0) y | 1.98E-04 | 7.28E-05 | 4.32E-02 | 1. |
| Compare | 42 Mo 99 | 2.7475 (± 4) d | 1.91E-04 | 6.85E-05 | 6.18E-02 | 5. |
| Compare | 52 Te 129m | 33.6 (± 1) d | 1.87E-04 | 6.55E-05 | 5.65E-03 | 4. |
| Compare | 51 Sb 126 | 12.4 (± 1) d | 1.80E-04 | 6.21E-05 | 2.22E-04 | 7. |
| Compare | 54 Xe 133m | 2.188 (± 11) d | 1.72E-04 | 6.25E-05 | 2.16E-03 | 1. |
| Compare | 1 H 3 | 12.33 (± 2) y | 1.42E-04 | 1.09E-05 | 1.42E-04 | 6. |
| Compare | 61 Pm 151 | 1.1833 (± 16) d | 1.40E-04 | 4.79E-05 | 7.76E-03 | 1. |




Comparison of fissioning system | Libraries

Cs-137 for Pu-239 Thermal fission JEFF-3.1 library

S: Spontaneous fission
T: Thermal neutron induced fission
F: Fast neutron induced fission
H: High energy (14 MeV fusion neutrons) neutron induced fission

| | JEFF-3.1-Pu239T | Pu239F | U235T | U238F | U233F |
|---|---|---|---|---|---|
| Independent Yield | 4.57E-03 | 6.95E-03 | 7.22E-04 | 4.36E-05 | 9.21E-03 |
| Error (I) | 1.62E-03 | 2.48E-03 | 2.56E-04 | 1.59E-05 | 2.83E-03 |
| Cumulative Yield | 6.59E-02 | 6.35E-02 | 6.22E-02 | 6.02E-02 | 6.50E-02 |
| Error (C) | 8.03E-04 | 1.21E-03 | 6.94E-04 | 1.52E-03 | 3.12E-03 |
| Y(A) | 6.71E-02 | 6.45E-02 | 6.24E-02 | 6.21E-02 | 6.58E-02 |
| Error (A) | 1.29E-02 | 1.25E-02 | 1.25E-02 | 1.20E-02 | 1.27E-02 |

# Overview

Nuclide Charts

Karlsruhe Chart of Nuclides

Nucleonica Charts eCharts

- **Universal Nuclide Chart (UNC)**
- **Nuclide Explorer**

Nuclear Data Sheets

Nuclear Data Search (Nuclide, Radiation)

Fission Yields Module

Exercises

# Exercises

## Universal Nuclide Chart

1. In the decay chain of U-238 find the nuclide which emits gamma photons with 1001 keV.

(Pa-234m)

2. In the decay chain of U-235, Ac-227 has alpha decay with BR 1.38% to Fr-223. Switch of all decays from the display which have less than 2% branching ratio.(MinBR%=2)

3. Switch off the blinking of the Tl-208 on the decay chain of Th-232.

# Exercises

**Nuclide Explorer**

1. Switch the colour scheme of Nuclide Explorer to Binding Energy and switch it back to Karlsruhe.

2. Switch off the colour of all radioactive nuclides. Switch it on after.

3. What are the daughters of Cs-137? (Ba-137, Ba-137m)

**Nuclear Data Sheets**

1. What are the daughters of Cs-137? What is the most important gamma line of Cs-137?(283.5 keV, EP=5.8E-6)

2. What is the daughter of Ba-137m? What is the most important gamma line of Ba-137m?(661 keV, EP=90.1%)

3. For the decay of Pu-239, what is the maximum alpha particle energy?(5.156 MeV)

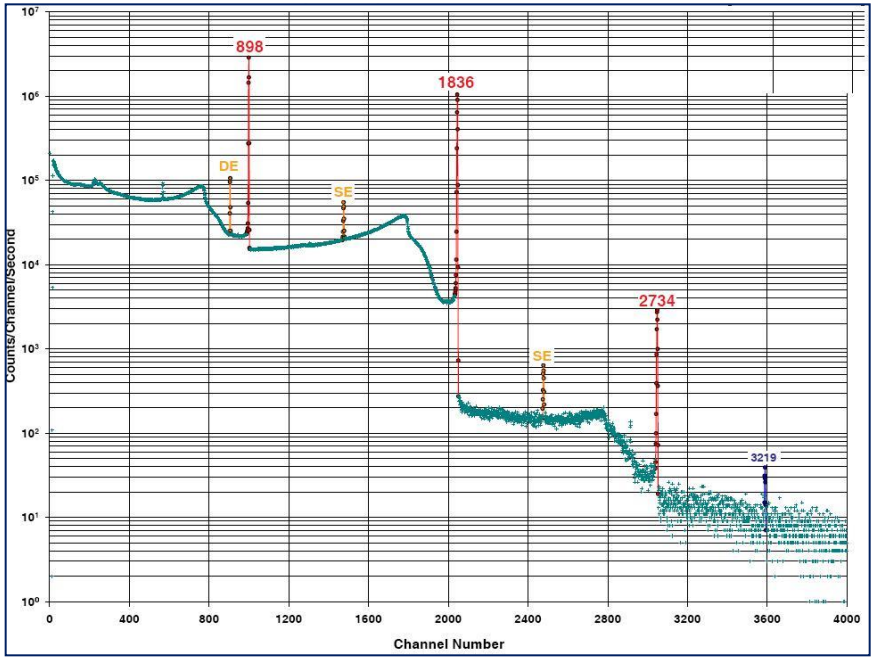
# Exercises

## Nuclear Data Search

1. Find the nuclides with gamma lines at 81, 303 and 356 keV with an uncertainty of ±1 keV. (Pa-228, Ba-133)

2. Find the Cs isotopes which weeks -100 years.
(Cs-134. Cs-137)

3. See gamma spectrum below – to which isotope does this correspond?
(Y-88 or Rb-88)



# Exercises

## Fission Yields

1. Find the thermal neutron fission products of U-235. How many fission products are listed in JEFF?

(977)

2. Which fission products have the highest yields? Give cumulative and independent.

(Te-134, Xe-134)

3. What is the cumulative fission yield of Cs-137?

(6.22E-2 or 6.22%)